Vol. 15 No. 5 May 1961

Published Monthly

INSTRUMENT PRACTICE

CONTROL SYSTEMS - ELECTRONICS - AUTOMATION

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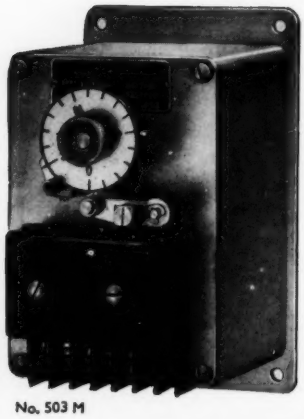

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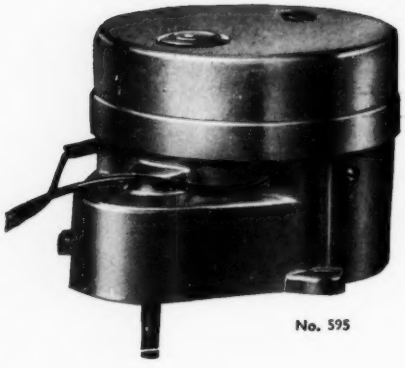
every type of movement

for scientific instruments



No. 595

Meters	POINTERS
Electric clocks	DIFFERENTIALS
Telephones	PINIONS
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Measuring instruments	COMMUTATORS
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Relays	

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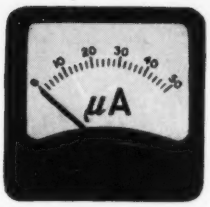

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'ENGLISH ELECTRIC' instruments

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INS. 59

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GD626

CAN YOU

MEET D.E.F. 5011?

D.E.F. 5011 and many other government specifications call for the use of vibration test equipment. Fatigue and resonance search tests are the principal applications but there are several more. In fact, vibration equipment is a design and test facility which is rapidly gaining in scope and importance throughout industry. But for all that, the techniques are still comparatively new and, not unreasonably, present unfamiliar problems to many manufacturers.

We specialise in both the manufacture of such equipment and the technology of its applications. Our range is the most complete in Europe.

If you can't meet D.E.F. 5011 or other government specifications requiring the use of vibration test equipment. Or if you want to be better equipped to do so ... **meet us.**

GOODMANS

the vibration specialists

GOODMANS INDUSTRIES LTD. AXIOM WORKS, WEMBLEY, MIDDLESEX, ENGLAND

Wembley 1200 (8 lines) · Cables: Goodaxiom, Wembley, England

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In addition to the vibration generators there is a corresponding range of oscillators and power amplifiers

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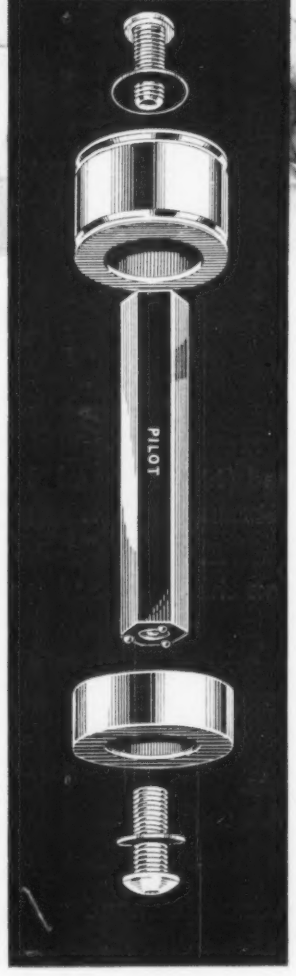
1·010" to 10" dia.
or larger



PILOT PRACTICALITIES

No. 3 of a series of advertisements to acquaint engineers with the very practical advantages of PILOT PLUG GAUGES designed to ***reduce*** gauging costs — When the series is complete they will be made available in folder form and sent free of charge to those interested. Unlike the B.S.1 recommended design, for gauges in which the cumbersome taper lock is continued up to 2½" diameter—

PILOT change to the patented TRI-BALL fixing at 1·020" diameter ensuring that the GO end is reversible so that its effective life is almost doubled by turning the worn front end around and presenting the relatively unworn back end for use. The gauge end is positioned upon the handle by the patented TRI-BALL method which in effect provides three universal joints, thus overcoming possible distortion to the gauge ends so frequently encountered when fixed by the pyramids of the tri-lock design. Because of the small area of contact between the balls, the handle, and the gauge end, heat transmission from the handle to the gauge end is practically non-existent. For a small extra charge two EASY ENTRY PILOT grooves can be incorporated at each end of the 'Go' as shown in the illustration and the gauge will not jam but "fall in".

"PRACTICALLY" PERFECT

603 Cogent

THE PILOT PLUG GAUGE CO LIMITED • SWALLOW ROAD • COVENTRY • PHONE: 87341/2

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ARROW

RELAYS

30 CIRCUIT ARRANGEMENTS ON STANDARD BASE

FRONT WIRING | ENCLOSED | BACK WIRING

Arrow Relays are C.S.A. approved (No 13336 at 110 volts A.C.) and embody these outstanding features:

- **Up to 30 circuit arrangements on the standard base.**
- **Available for surface mounting, back of panel wiring or enclosed.**
- **Completely silent in service.**
- **Silver to silver butt type contacts.**

Arrow Relays are rated up to 10 amps per pole at 230v. A.C. Operating coils, of low wattage consumption and continuously rated, are available for 6 to 550v. A.C. and 6 to 230v. D.C.

See the full range of ARROW instrument switches on Stand 500 at the R.E.C.M.F. Exhibition

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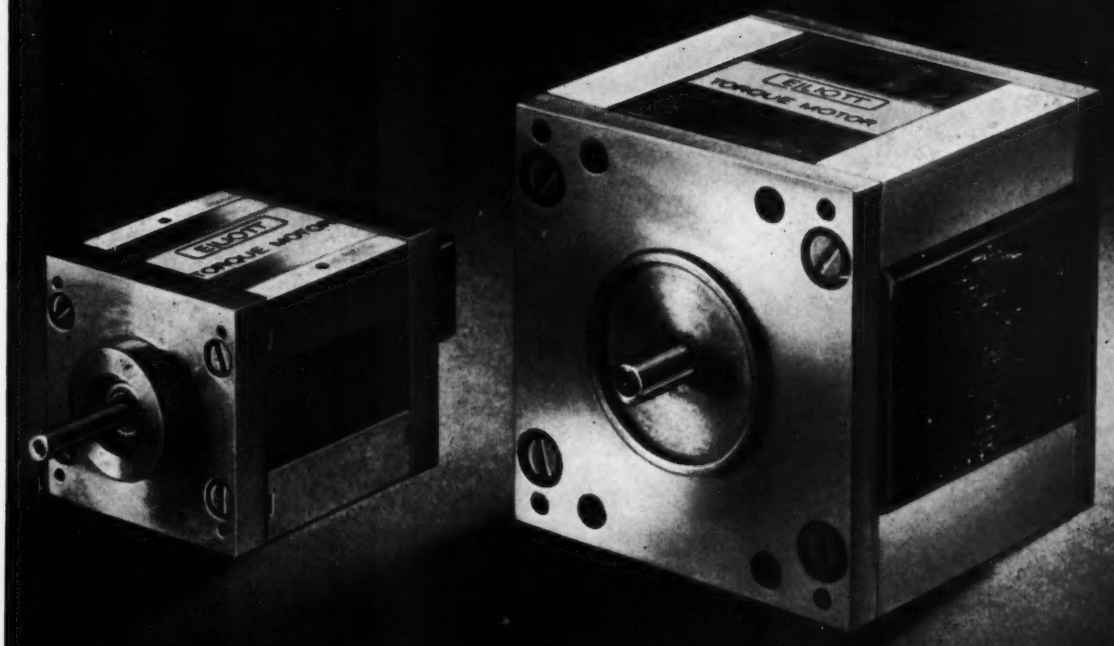
Torquemotors



For your precise control requirements, **Elliott Torquemotors** are now available on short delivery at prices lower than any similar units.

Years of design and production experience guarantee reliability in the most arduous military and industrial applications.

The Elliott range includes the powerful Type 212 Motor which develops 5000 gm. cms. at zero deflection for its rated series current and the new Type 130 motor of only 1.3 inch cube incorporating special electrical and mechanical features making it the most advanced torquemotor on the market.

Our latest design developments ensure that **Elliott Torquemotors** will meet your future instrumentation and control requirements.

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ELLIOTT BROTHERS (LONDON) LTD
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EA *A member of the Elliott-Automation Group*

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MAJOR PRICE R

IN THE RANGE OF

AEI

Pneumatic Instruments

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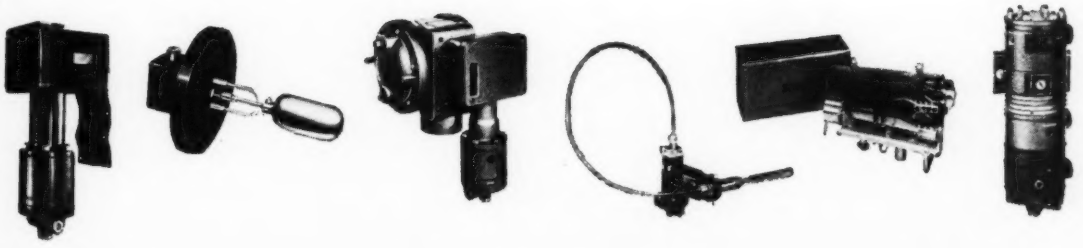
IODIVISION ANNOUNCES

CREDUCTIONS

A programme of increased sales coupled with extensive forward planning of production has enabled considerable economies to be achieved in the manufacturing costs of many AEI pneumatic instruments. The benefit of these reductions is being passed on to users in the form of revised prices as from May 1, 1961.

For details of these new prices and of current delivery times, contact:

AEI Instrumentation Division, Process Control Department, P.O. Box No. One, Harlow, Essex. Telephone: Harlow 24231.



AEI

Instrumentation Division
Associated Electrical Industries Limited

SC/133

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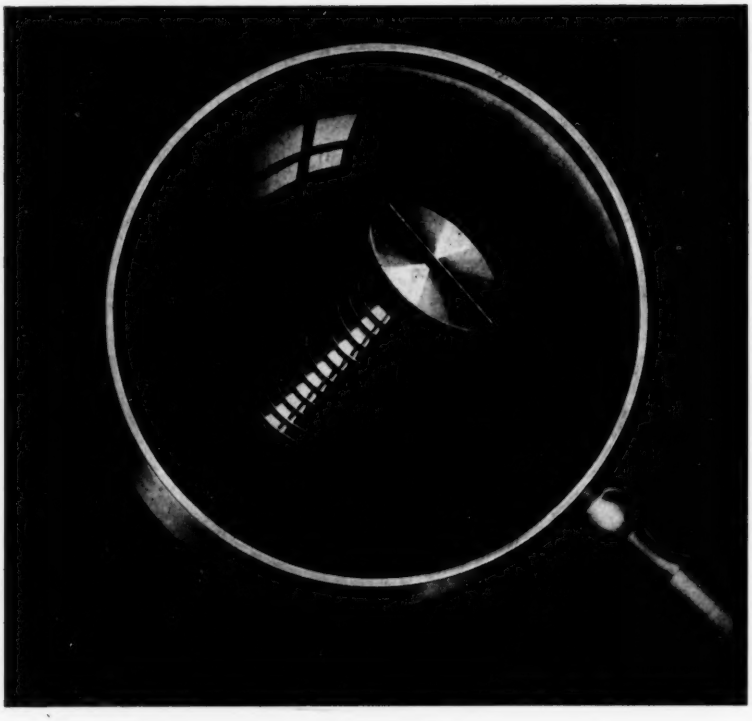

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NEW

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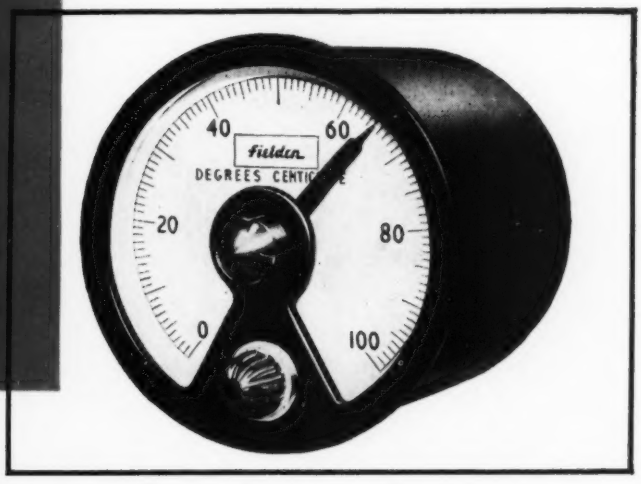
TRANSISTORISED

Temperature Control

to within 0·5°C

73 TEMPERATURE RANGES available between −200°C and +850°C with dials accurately calibrated in °C or °F. Scale length 9" with temperature spans down to 50°C or 100°F. Easily set to required control temperature.



LOW COST — electronic accuracy and stability at a new low price.

TRANSISTORISED for exceptional reliability. Operates from 12 volt battery or normal mains supply.

INTRINSICALLY SAFE version available.

REALLY ROBUST. Sealed case with no pivots, galvos or other delicate moving parts. Temperature sensing bulb is platinum resistance housed in stainless steel sheath, tested to 2,000 p. s. i.

EASILY FITTED. Simple clamp mounting. Can be mounted at any angle. Robust terminals for connection of simple electrical wiring.

REMOTE OPERATION. Controller can be a few feet or 300 feet away from the temperature measuring point — no adjustments required and response is immediate.

HEAVY DUTY CONTACTS — Change-over electrical contacts rated at 5 amps. A.C. with quick make and break action. Pneumatic control available if required.

HIGH STABILITY — Control points will not vary over many years service. Unaffected by ambient temperature changes or by wide variations in supply voltage.

MODERN AND COMPACT — Circular meter-type case. Occupies panel space of only 4¼" diameter. Bold pointer shows control temperature. Red lamp, visible from sides and front, indicates control action.

QUICK DELIVERY — many ranges available ex stock. Telephone your urgent requirements to Manchester, Wythenshawe 3251; London, Trafalgar 3154; Walsall 28343; Stockton 68617; or Edinburgh (A. R. Bolton & Co Ltd) Craig Lockhart 5235.

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Send for specification sheet BIK 1/1P and price list

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instrument bearings... fitted exclusively to

THE MARCONI MARK IV TELEVISION CAMERA

NEW ADVANCE

Sensitivity, stability, consistency, and reliability—all are qualities of the new Marconi Mark IV television camera based upon a 4½ inch image orthicon pick-up tube.

The Marconi Mark IV has an exceptionally good performance under either natural or artificiai light, and such high stability of circuitry that a consistently high quality picture can be held without frequent re-adjustment of controls. In the B.B.C. Studio Number Three, the vision control officer is responsible for the controls of up to six Mark IV cameras. Obviously, each and all of these must be unfailingly consistent in optical and electrical performance. Equally their mechanisms must respond smoothly and instantaneously to the requirements of control. Here fourteen Hoffmann bearings play their part, ranging from $\frac{3}{16}$ to $\frac{7}{8}$ of an inch bore.

They are depended upon to give ease and smoothness of movement in such vital components as the Turret Mechanism, the Focusing Mechanism, and the Remote Iris Mechanism and Filter Kit.

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BALL AND ROLLER BEARINGS

Hoffmann Technical Service is freely available; we shall be pleased to help in your next project.

BRANCH OFFICES AND STOCKROOMS IN ALL PRINCIPAL TOWNS

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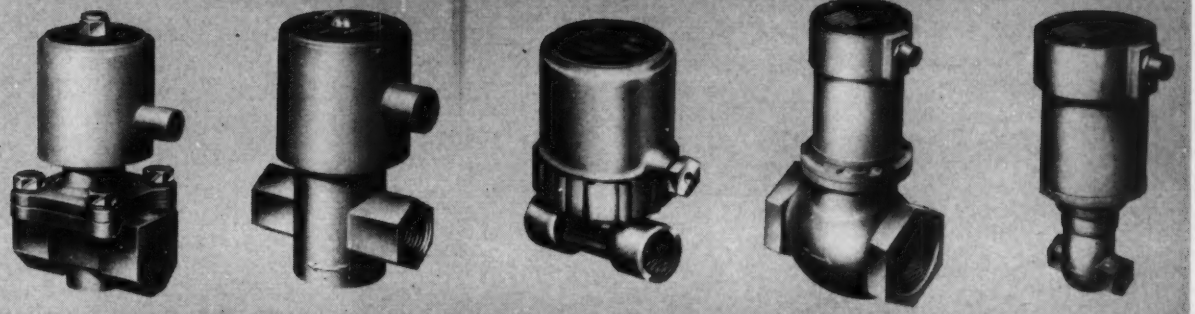
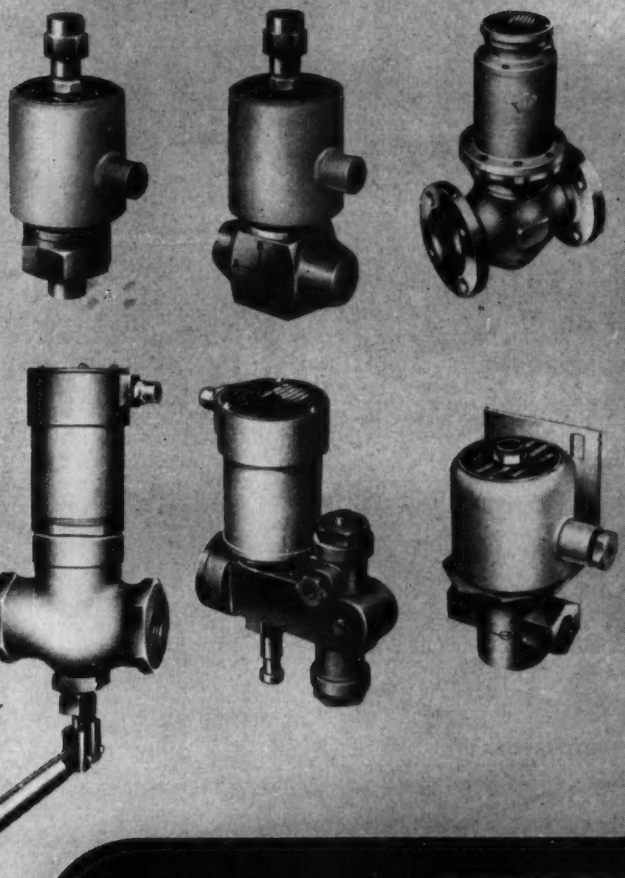


For any type of SOLENOID VALVE — whatever your need



SPECIALS made to suit customers' requirements

If the solenoid valves you require are not included in our comprehensive standard ranges, our Design Engineers will gladly develop special types to suit your requirements. Whatever your need, send us your enquiries for prompt attention.

Specially designed for use in a Nuclear Power Station, this 3-way valve, made entirely from stainless steel, controls radio-active heavy water at a pressure of 17 atmospheres and at a temperature of 250°C.

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LIMITED

ETHER LTD., *Combustion Safeguard and Solenoid Valve Division,*
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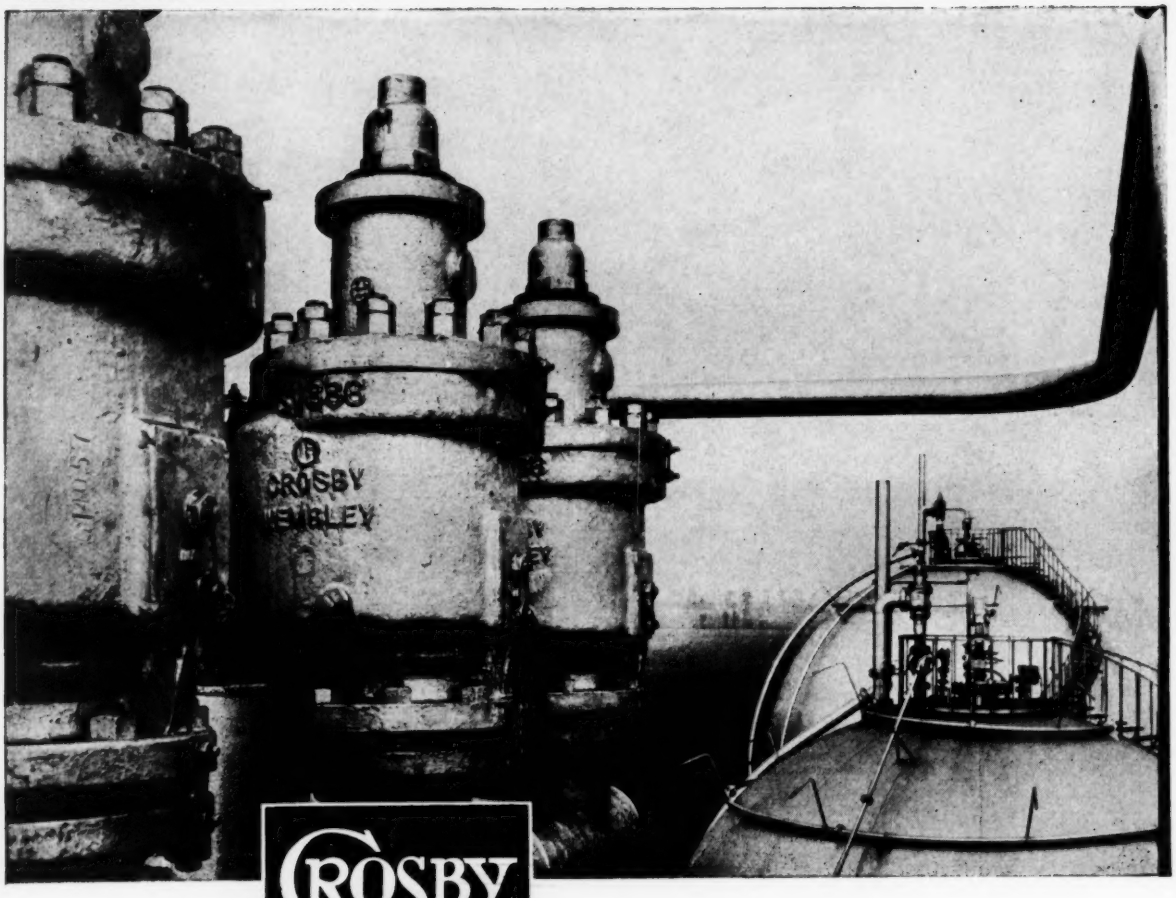

CROSBY

MASONEILAN

SHELL USE EQUIPMENT AT SHELL HAVEN

Illustration shows three of four 6 x 8 Crosby Relief Valves together with Masoneilan Liquid Level Transmitters mounted on each of three Butane Storage Horton Spheres at Shell Haven. These relief valves protect the tanks from overpressuring.

The level instruments transmit the level of liquid Butane in the Spheres back to the Receiver in the control room. The reliability of this equipment is thus exemplified once again by one of the major oil companies of the world.

IMPORTANT ANNOUNCEMENT

Details are now available of the Crosby portable self-contained Safety Relief Valve Test Stand for Works or Site test purposes.

CROSBY VALVE & ENGINEERING CO. LTD., CROSBY WORKS, WEMBLEY, MIDDLESEX

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CHWR/1960/1a

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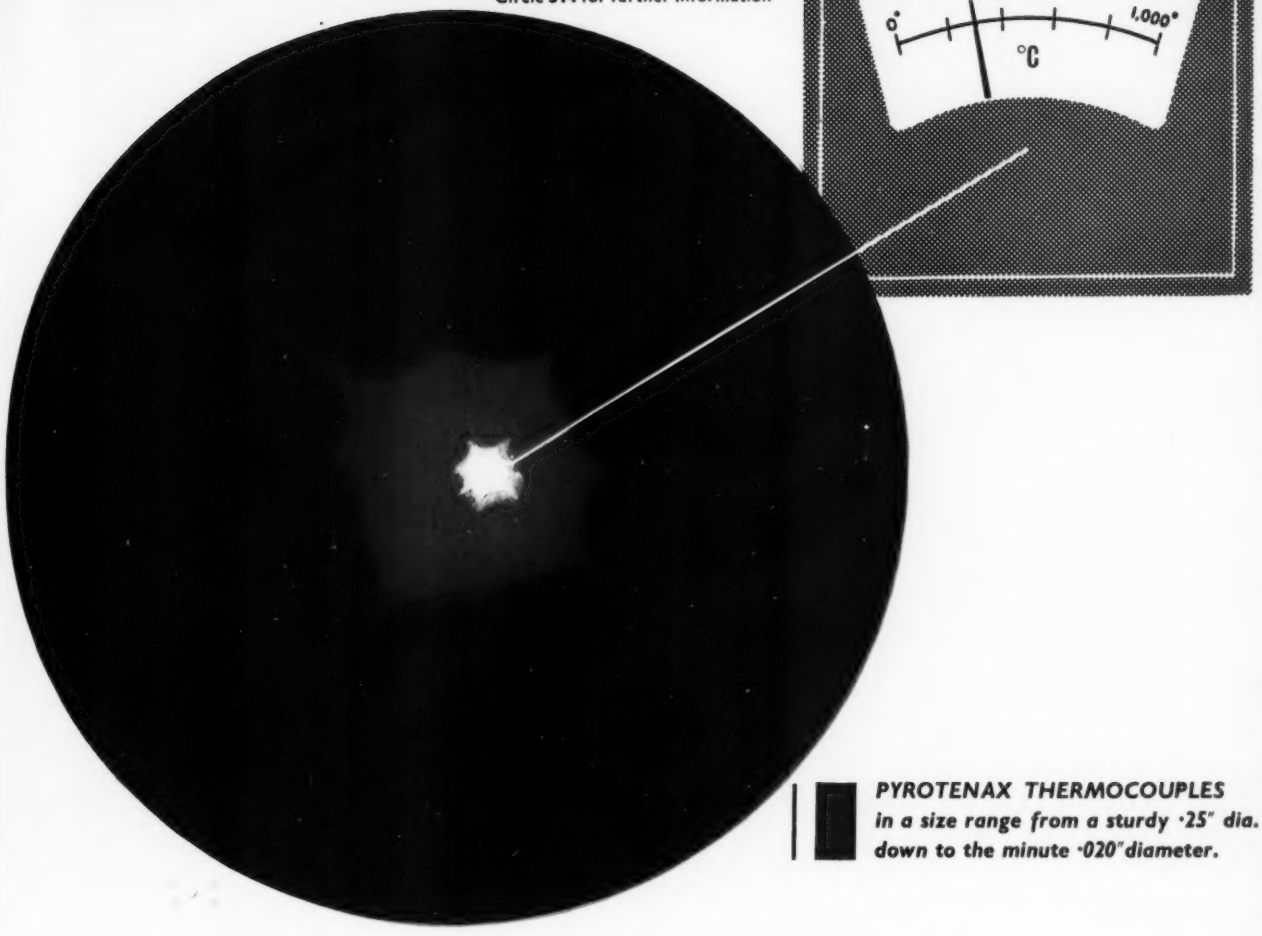

***PYROTENAX THERMOCOUPLES** in a size range from a sturdy ·25" dia. down to the minute ·020" diameter.*

There is something here for every industry where temperature has to be measured—

The inherent qualities of Pyrotenax thermocouples, which were essential to the exacting requirements of nuclear power, are equally attractive to the industrial user. The temperature range is sub-zero to 1100°C., sizes ·25" down to ·020", with many alternatives of sheath and conductor metals.

- *Small overall diameter*
- *Rapid Response Rate*
- *Easily bent to shape*
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- *Long life—inexpensively replaced*

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PERFECTED BY EXPERIENCE
Pyrotenax
m.i. THERMOCOUPLES

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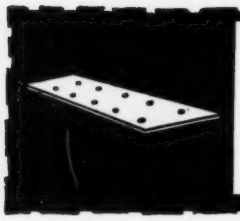
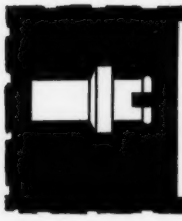
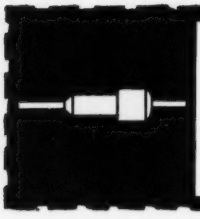


TERMINAL BOARDS



LUGS



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HARWIN

Harwin *make* components—*specialise* in components. Lugs, moulded insulators, terminal boards and chassis furnishings. 'Off-the-shelf' or to special design.
The *quality* of every Harwin component is the product of experienced, precision manufacture and rigid inspection—meeting, and in many cases surpassing standard specifications. In addition, Harwin *service* and *specialisation* in fulfilling individual needs is something to be experienced—talk over *your* component problems with Harwin and be sure of the *best* and most *effective* answer.

SERVICE AND QUALITY

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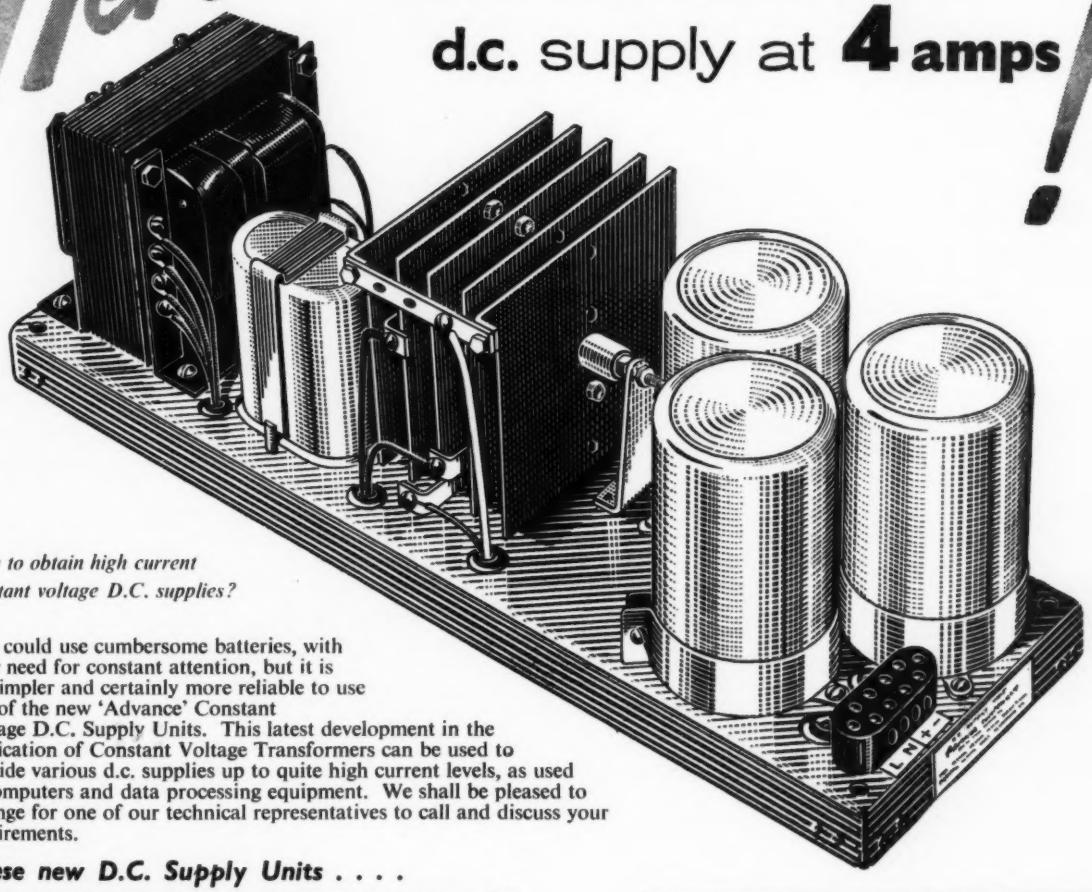
Here is a 12v. stabilized d.c. supply at 4 amps!



How to obtain high current constant voltage D.C. supplies?

You could use cumbersome batteries, with their need for constant attention, but it is far simpler and certainly more reliable to use one of the new 'Advance' Constant Voltage D.C. Supply Units. This latest development in the application of Constant Voltage Transformers can be used to provide various d.c. supplies up to quite high current levels, as used in computers and data processing equipment. We shall be pleased to arrange for one of our technical representatives to call and discuss your requirements.

These new D.C. Supply Units . . . .

- Provide **HIGH CURRENT OUTPUT AT LOW COST**
- Are **SMALL IN SIZE AND WEIGHT FOR VA OUTPUT**
- Have **HIGH ENERGY RESERVOIR,** thus are suitable for pulse, intermittent or variable loads
- Operate with **HIGH EFFICIENCY**

TYPE	OUTPUT	RATINGS	Nett Prices in U.K.
DC.1	6 volts	1.25 amp	£20
DC.2	6 volts	4.00 amps	£25
DC.3	12 volts	1.25 amp	£20
DC.4	12 volts	4.00 amps	£27
DC.5	24 volts	1.00 amp	£20
DC.6	24 volts	5.00 amps	£30
DC.7	48 volts	1.00 amp	£20
DC.8	48 volts	4.00 amps	£35

Advance CONSTANT VOLTAGE

D.C. POWER SUPPLIES

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Level Indication
and Control
with
1 Instrument
GALLONS
Remote Indicator Circuit
Alarms & Control Circuits
HIGH
LOW
The
LEVELRATOR
regd. trade mark
High Level
Levels independently adjustable
1 Electrode serves 3 operations
Low Level
This instrument gives continuous indication, control, as well as visual and/or audible alarm for free flowing solids and liquids.
The instrument uses one electrode for both indication and control.
The alarm points can be set to operate over the full length of the electrode to suit the particular application.
The Electronic Dip-stick or Electrode-System can be of the rigid variety for small vessels but for containers up to 60 ft. a special duty flexible type electrode is available.
By the use of the specially designed electrode system, good accuracies and near linear scales can be achieved.
Location.
The 'Levelrator' can be situated up to 150 ft. from the electrode system.
The instrument has a built-in calibrating meter.
Remote indicators can be supplied to customers' requirements and sited anywhere on plant.
The high or low level control points are completely independent of the indicating meter.
The specially designed 'Multipoint Levotog' up to 20 points, is available where centralisation of equipment is desirable.
Save Man Hours (Automatic Control)
Save Materials (Accuracy)
Save on Installation Costs
(only one controller, one electrode)
Save Money (one instrument only)
LEVELRATOR

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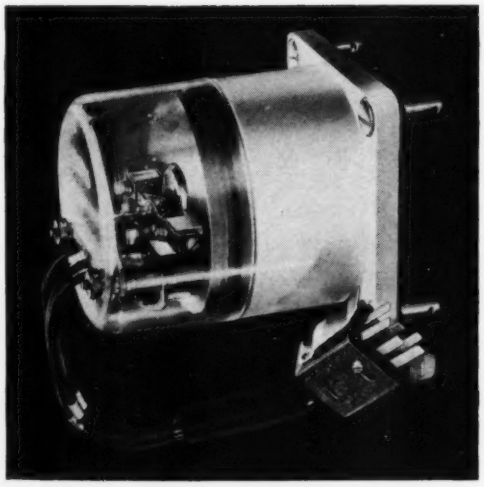
rugged robust reliable

plus all the accuracy you need



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Once you fix a SMITHS Automatic Protection Unit you can forget it. They are really rugged units which stand up to the toughest assignment. Day in, day out, they'll keep watch for you—without you watching them. Suitable for all power driven plant, protects against damage resulting from:—

Rising or falling voltage—current or speed
Excessive Crankshaft speed
Failure of lubrication system
Failure of cooling system

SMITHS Automatic Protection Units can be fitted to Drilling Rigs, Pumping Machinery, Diesel Generator Sets etc., and are in use on Marine and Rail Traction and for N.A.T.O. Defence Equipment.

fit and forget | SMITHS automatic protection units
they're built to last . . . and last

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Preformations Limited offers a unique design engineering service and will undertake the research necessary for the development of special magnets to meet specific requirements. Write for the Magloy brochure—on company headed notepaper please.

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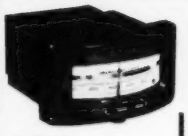


TYPE 990:
Two-position on/off.

Operating:
Solenoid valves.
Motorised valves.
Contactors. Relays.
Electric heaters.

Applications:
Salt-baths for heat-treatment of metals.
Vitreous-enamelling furnaces.
Muffle furnaces.
Hot-air ovens.
Drying kilns.
Crucible furnaces.
High-temperature alarms.
Extruding and moulding machines, etc., etc.

TYPE 991:
Anticipatory

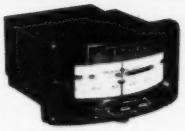
Operating:
Solenoid valves.
Motorised valves.
Contactors. Relays.
Electric Heaters.

Applications:
Extruding machines and moulding presses for plastics, rubber, etc.

Die-casting machines.

Furnaces for crystal growing.

Chemical processing.
Food packaging machinery, etc., etc.



TYPE 992:
Proportioning (stepless)

Operating:
Saturable reactors.

Applications:
Electrically-heated equipment requiring extremely accurate temperatures, e.g. plastic extruders for high-quality production.

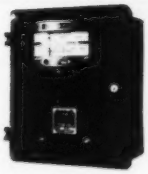
Electric furnaces employed on research.

Electronic production, etc., etc.

TYPE 993:
Three-position (employing any combination of the preceding control systems).

Operating:
Solenoid valves.
Motorised valves.
Contactors. Relays.
Electric heaters.
Saturable reactors.

Applications:
For the independent control of sequential heating and cooling or for controlling a floating valve in:—
Salt-baths for heat-treatment of metals.
Vitreous-enamelling furnaces.
Muffle furnaces.
Crucible furnaces.
Extruding machines.
Moulding presses.
Die-casting machines, etc., etc.



TYPE 995:
Continuously-acting Proportional (with manual reset)

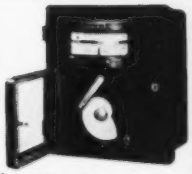
Operating:
Motorised proportioning valves.

Applications:
Gas-fired or oil-fired molten-metal vats.

Continuously-fed furnaces.

Lehrs.

Drying ovens and kilns, etc., etc.



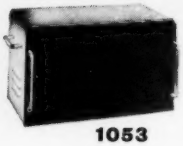
TYPE 994:
Time-Temperature (employing any one of the preceding control systems).

Operating:
Solenoid valves.
Motorised valves.
Motorised proportioning valves.
Contactors. Relays.
Electric heaters.
Saturable reactors.

Applications:
For controlling the rise and fall of temperature over a given period o time in:—
Pottery kilns.
Food processing.
Heat-treatmentofmetals, glass, plastics.
Research, etc., etc.

Circle **321** for further information

1022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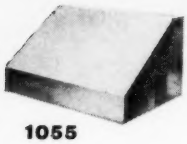
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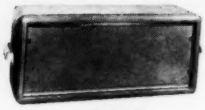
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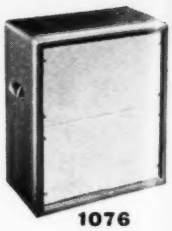
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The perfect frame for your instruments is a *Standard Case* from

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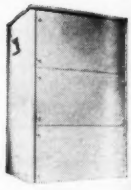
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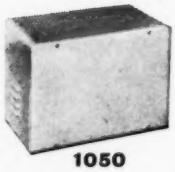
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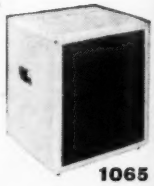
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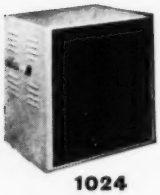
IMHOFS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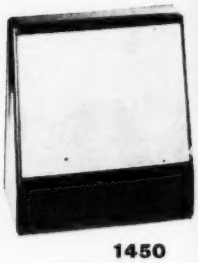
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Save valuable time and money by using one of the Imhof Standard Cases. Choose your exact requirements from a selection of over 60 different cases.

Use Imhof Standard Cases and cut out tooling costs, at the same time reducing drawing office time to a minimum.

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Send today for full details of our Standard range which includes a tremendous choice of handles and accessories as well as raks, consoles, cases and miniboxes.

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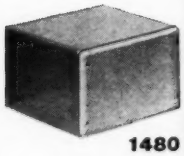
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Sweden: Electronlund AB, Malmo 1
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Tunisia: E.G.E.E., Paris (19)
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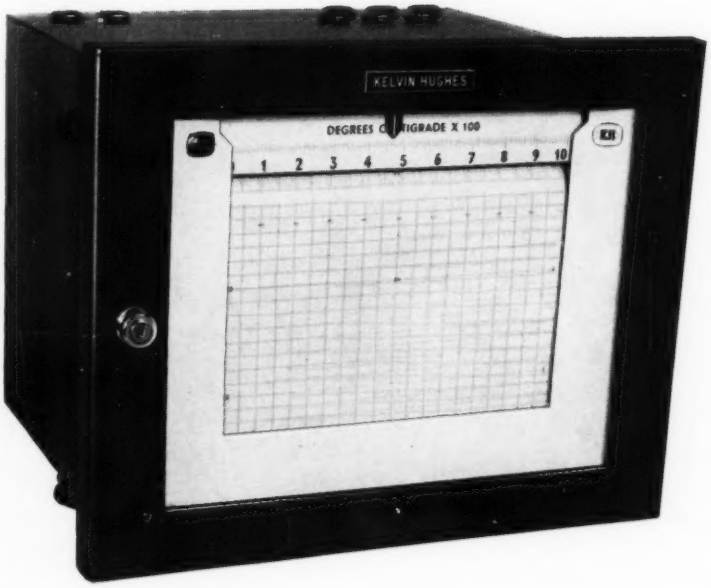
Circle **322** for further information

NO SLIDE-WIRE

NO wear to impair accuracy with SMITHS

NEW POTENTIOMETRIC RECORDERS



Consider these features

★ No Slide-wire: Unique design of measurement dispenses with conventional slide-wire, eliminating wear and ensuring trouble-free service.

★ Infinite Resolution: Variable force balance current generator gives improved performance in sensitivity and accuracy.

★ No Standardising: Highly stabilised zener-diode d.c. supplies obviate the need for standardising.

★ Dead-beat Balancing: Brushless tacho-generator eliminates overshoot.

★ Six Chart Speeds: 2, 4 or 8 in/hr. and 4, 8 or 16 cm/hr. selected by inter-change gear wheels.

★ Clear Chart Presentation: 8 in. long, 10½ in. wide chart exposed. Strip light optional.

★ Remote Indicators: Operated from basic instrument without adding secondary components.

★ Plug-in Range Changing.

★ Accessibility.

SMITHS introduce a series of new Potentiometric Recorders for continuous duty applications in industrial processes and laboratory investigations in research establishments. These instruments measure d.c. input voltages down to the range 0-1 mV, and are suitable for use with thermocouples, resistance bulbs, strain gauges, load cells and other transducers.

No slide-wire is used in the SMITHS system, thus the main source of wear and subsequent loss of accuracy inherent with other null-balance type instruments does not arise.

Available as single or multi-channel recorders for 2 to 12 input sources, these instruments offer many outstanding features, high accuracy and assured reliability at economic cost. Two-position or Three-position switching facilities for control or alarm operation can be added to the system.

Write now for fully descriptive literature

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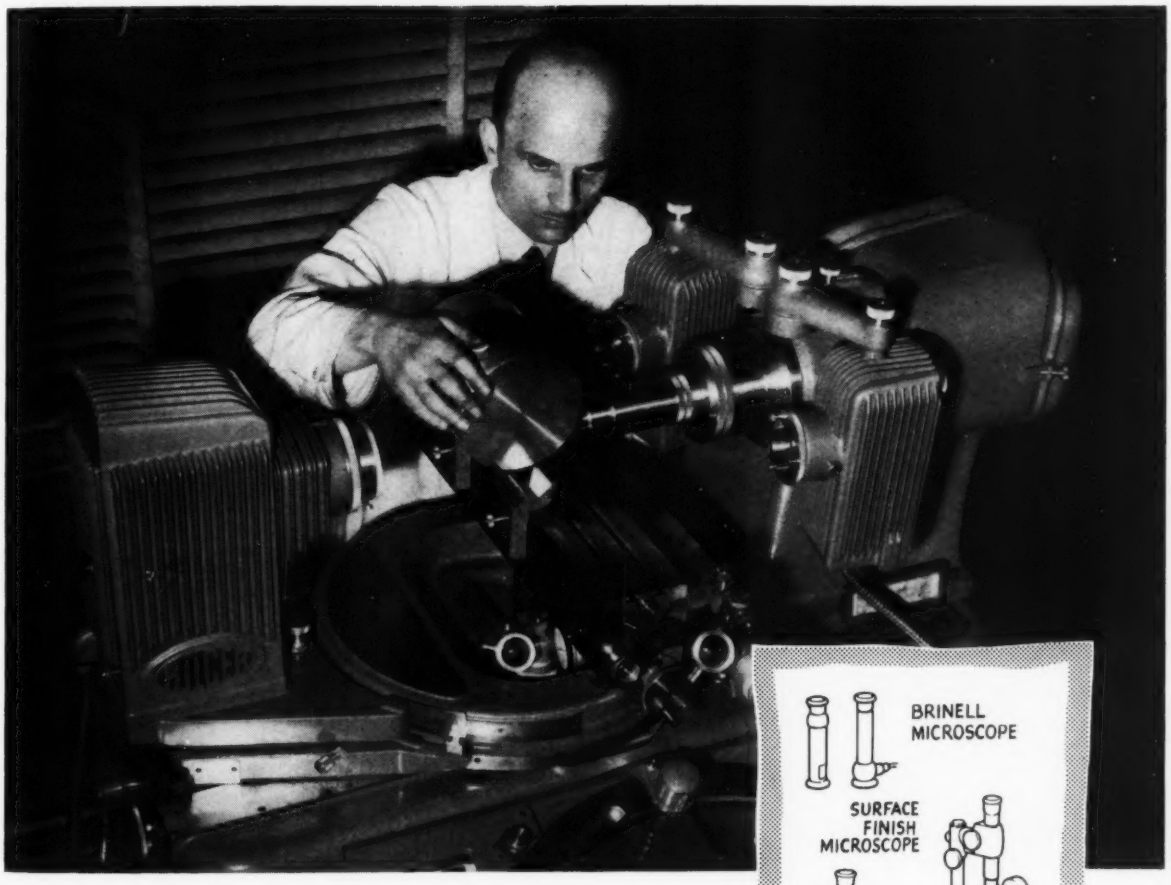
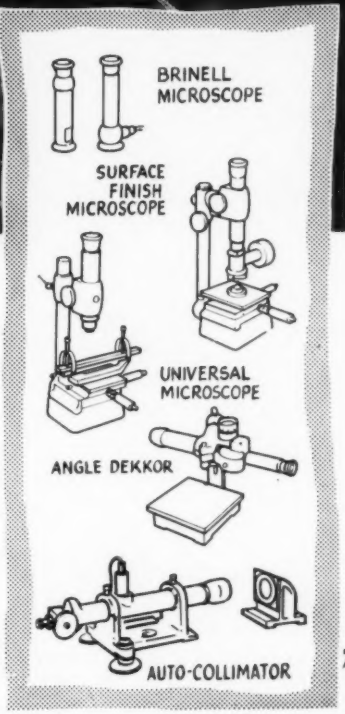
precision measuring instruments





Wide range fulfilling specific requirements in Toolrooms, Machine Shops and Research Establishments. Apart from those instruments illustrated the range includes:—

Projectors—Universal, Enlarger and Production types.
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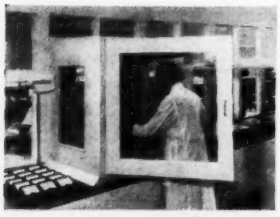
INCREASED PRODUCTION CAPACITY!

PERFECT CONDITIONS!

. . . result . . . SHORT DELIVERY!

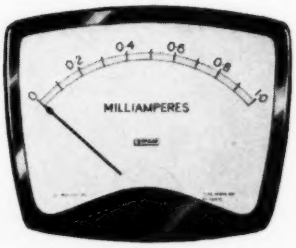
Pictured below, in descending order, are departments of the new Sifam factory shown at the foot of this page: Electrically Interlocking Hatch from Ultrasonic Cleaning Dept. to Clean Area; Dust-free Air-Conditioned Final Assembly Area; Compression Moulding Shop; Preliminary Assembly Shop and Dial Dept.



The concentration under one roof of exceptionally able design teams, with long experience in many fields of industrial instrumentation, supported by completely up-to-date research and production resources, is an outstanding feature of the new Sifam Factory. Designed solely for the specialist manufacture of electrical measuring instruments and pyrometers to the highest standards, the new plant offers an unrivalled service and a range of instruments unexcelled for craftsmanship and appearance.

Increased capacity enables us to offer the delivery you want—and to maintain it! Write to us now or ask for a Technical Representative to call with details of the latest Sifam developments.

The Wessex range of four instruments is attractively designed in the modern style. The illustration depicts Type 61.



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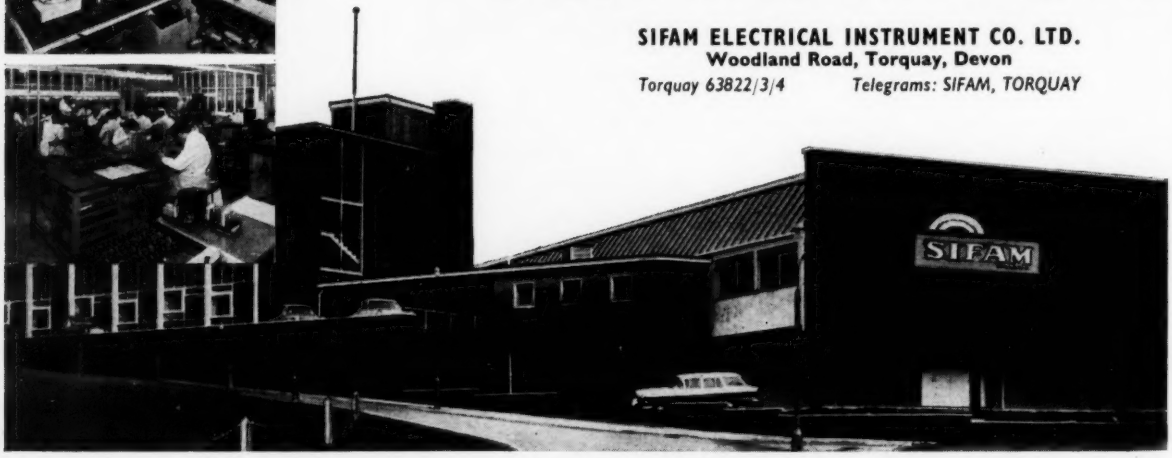

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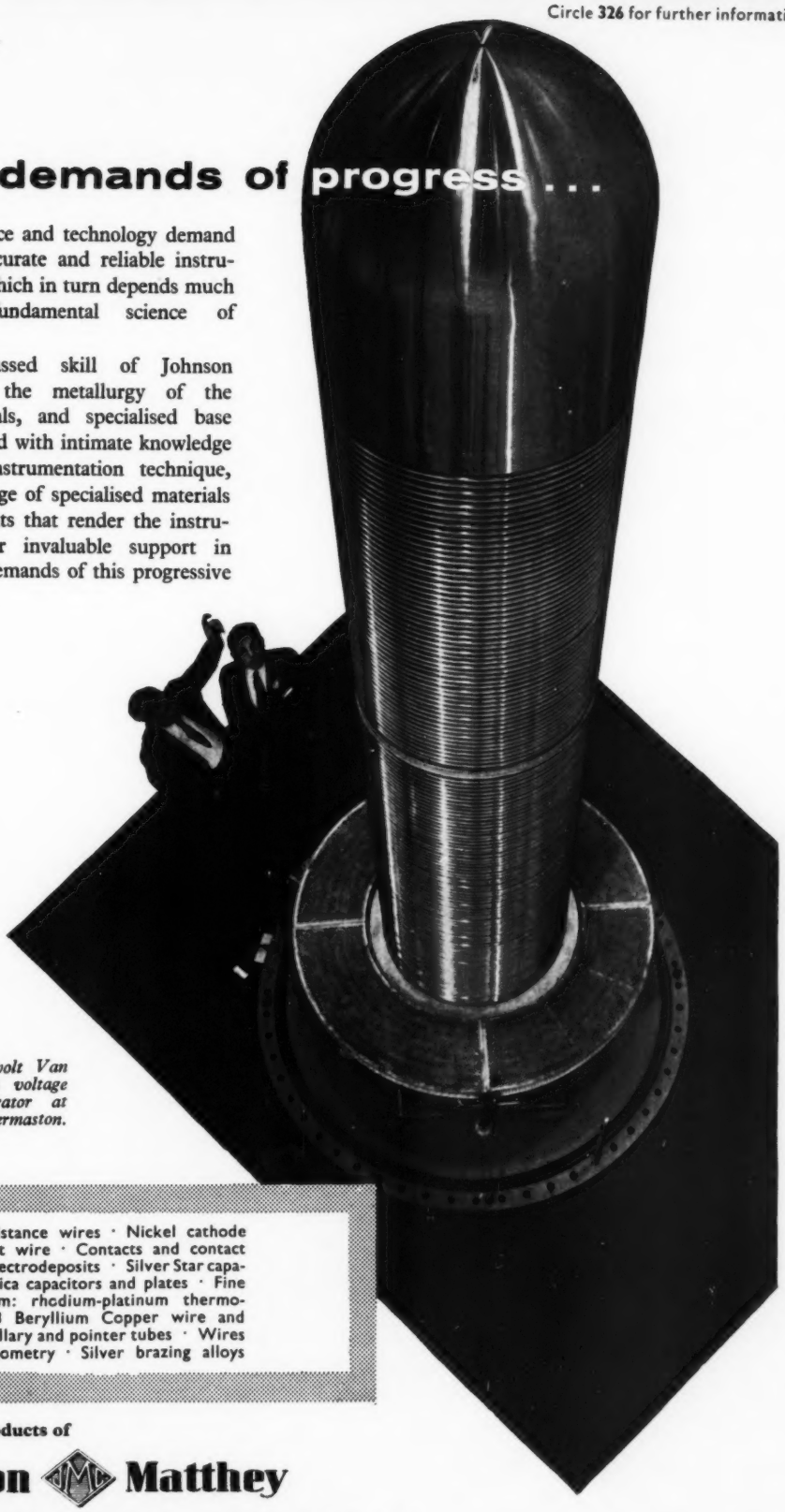
The demands of progress . . .

Nuclear science and technology demand ever more accurate and reliable instrumentation—which in turn depends much upon the fundamental science of metallurgy.

The unsurpassed skill of Johnson Matthey in the metallurgy of the precious metals, and specialised base metals, coupled with intimate knowledge of modern instrumentation technique, provides a range of specialised materials and components that render the instrument designer invaluable support in meeting the demands of this progressive age.



The six million volt Van Der Graaf high voltage electrostatic generator at U.K.A.E.A., Aldermaston.

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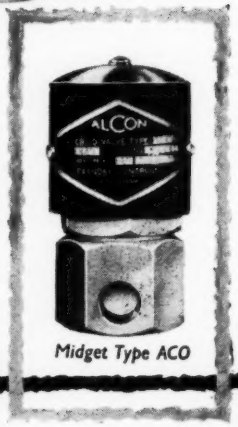
MIDGET TYPE ACO. Used all over the world for control of domestic oil burning. Sizes up to $\frac{3}{8}$ in. B.S.P., with self-contained by-pass if required.

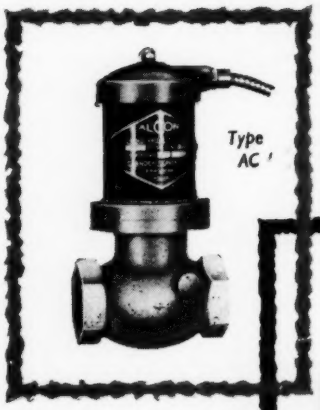
TYPE AC. Normally closed, opens when electrically energised. Sizes from $1\frac{1}{2}$ in. to 3 in. bore to control gas, air, oil, etc.

TYPE ACP. Servo Operated Piston Type. Will handle liquids and gases at high pressure with a small expenditure of electrical power.

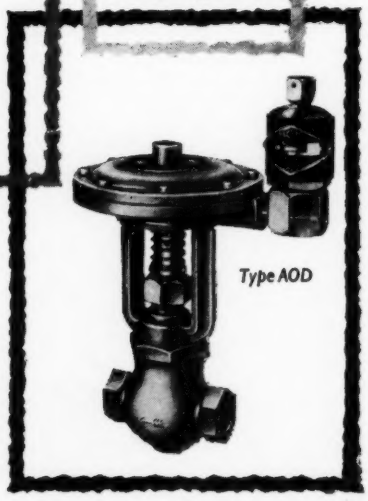
TYPE AOD. Heavy duty air operated units, individually designed for control applications beyond capabilities of Solenoid types. For pressures up to 1,500 p.s.i. Sizes $\frac{1}{4}$ in. B.S.P. - 8 in. bore.



Midget Type ACO



Type AC



Type AOD

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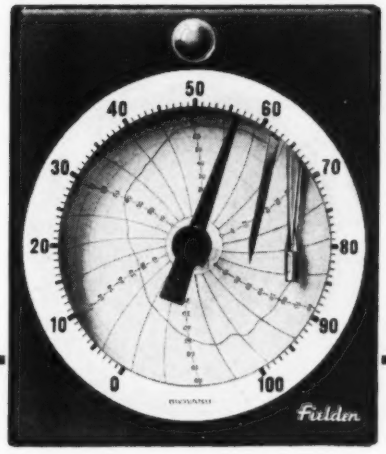
NEW "CAPACIPOISE" Recorder for current and voltage

Now, for little more than the cost of an ordinary moving coil recorder, you can install the Fielden Capacipoise Recorder. The pen and indicating pointer are driven by a robust servo motor and not directly by the moving coil meter. Thus the movement is freed from the load of the pen mechanism yet only a few microwatts input are needed for full scale deflection on the chart and scale.



LOW COST—A servo operated recorder at about half its previous cost.

TRANSISTORISED for complete reliability. 12 volts D.C. or normal mains operation. No warming-up period. Main electronics housed in sealed plug-in unit. Low power consumption.

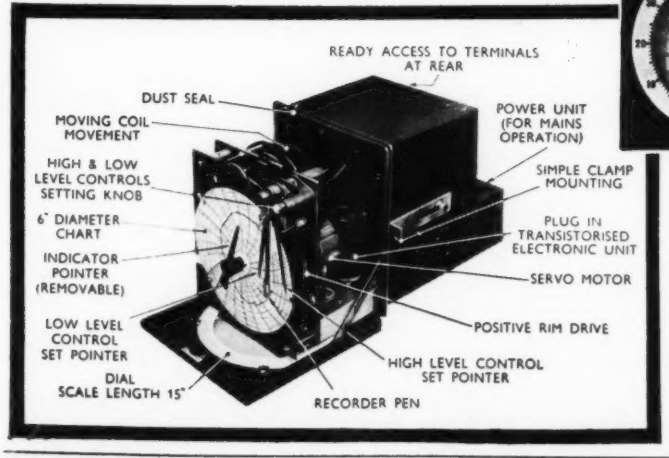
MODERN & COMPACT — Occupies less than ½ sq. foot of panel space. Easy to read 15" scale. 6" diameter chart.

SIMPLE, ROBUST "MECHANICS" — Moving parts reduced to absolute minimum. Positive rim-drive from servo motor to indicating pointer, with simple quadrant to the recording pen. Fast response — less than 1 second from zero to full scale deflection.

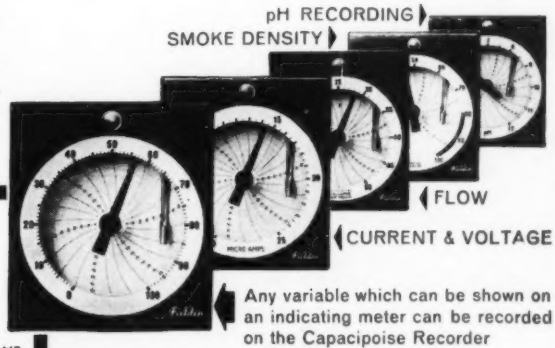
EASY TO INSTALL—Simple clamp panel mounting. Easy access to clearly marked terminals at rear.

3-STEP CONTROL if required. Can be either electrical or pneumatic.

HANDLES WIDE RANGE OF CURRENTS AND VOLTAGES — down to 25 μA or 30 mV D.C. for full scale deflection. A.C. current and voltage ranges also available.



SMOKE DENSITY, pH, CO_2, THICKNESS and FLOW RECORDING. The Fielden Capacipoise Recorder is used with detecting instruments made by many well-known suppliers.



Any variable which can be shown on an indicating meter can be recorded on the Capacipoise Recorder

Write for leaflet CAP 2/S/IP and price list

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10-Mc/s Transistorised

DIRECT READING DIGITAL FREQUENCY METER-COUNTER-TIMER TYPE SA 505

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For full technical specification write for Publication 181D.

WITH THESE OUTSTANDING FEATURES (Price £720 ex works)

- Direct frequency measured 0-10 Mc/s.
- Accurate period and time interval measurement.
- Self-contained Frequency Standard 1 part in 10^7.
- Clock pulse source.
- Operates remote read-out or digital printer.
- 9½" high x 13½" wide x 23" deep (25 x 35 x 59 cms.) Weight: 30 lbs. (13·6 kgms.).

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The demand created by the high quality of Weston meters is such that production techniques can be employed which enable these outstanding instruments to be produced at competitive prices.

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There is no head loss, the flow being unrestricted.

Accuracy within ±1% of the indicated reading.

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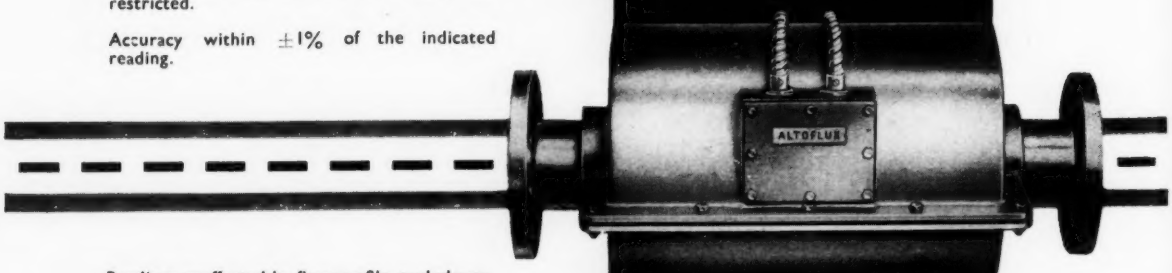

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now...a *transistorized* chopper

Price in the U.K. for small quantities, available from stock, £8.5.0d.
Unsealed versions of the SM.10 transistorized chopper are in use in the control systems of British Nuclear Power Stations and have already given three years trouble-free service — Thus proving their stability and reliability.

New from TMC comes the ELECTRONIC MODULATOR SM. 10 — the first fully encapsulated transistorized chopper to be produced and sold in quantity in Gt. Britain. The SM. 10 is a highly stable, clamp-type chopper with silicon transistors, designed for low level d.c. chopping. Unlike electro-mechanical choppers, the S.M. 10 has no moving parts to wear, or contacts to become contaminated. What is more, it will never need adjustment!

The SM. 10 has all these advantages:

- Noise level so low that it will switch a voltage of one microvolt.
- Extremely high stability over the temperature range 0° to + 55°C.
- Carefully matched, selected components give low drift and almost limitless life.
- Will operate from any 6 volt sinusoidal or square-wave supply—at frequencies from 40 c/s to 1000 c/s.
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- Epoxy resin cast and aluminium encapsulated — will withstand excessive vibration and shock effects (suitable for all military and commercial projects).

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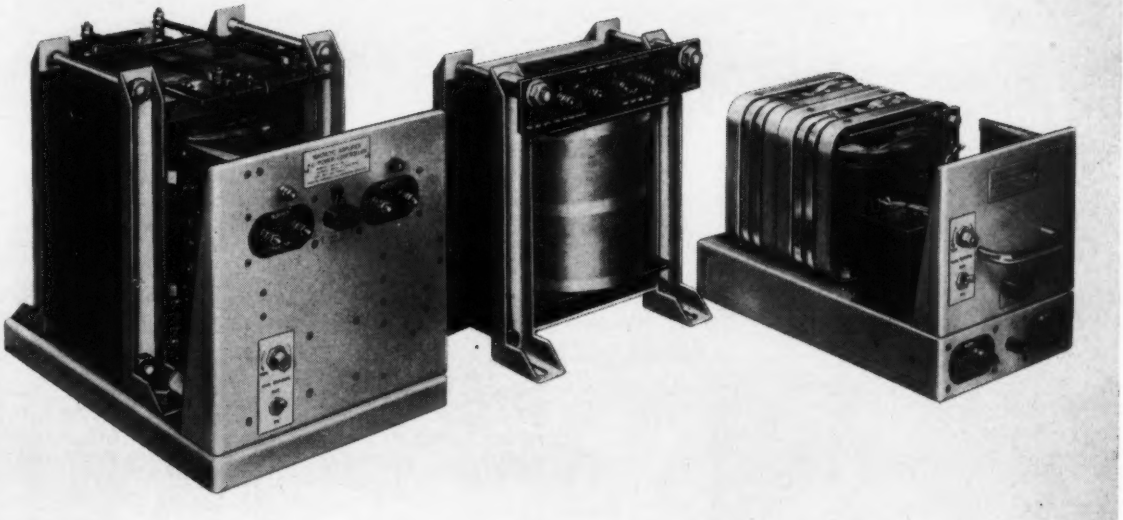
PARMEKO

MAGNETIC AMPLIFIER A.C. POWER CONTROL UNITS



These units have been designed to control A.C. power loads and find many applications in the controlling of power to furnace elements, incandescent lamps, rectifier equipments, etc. Being robustly constructed and containing no moving parts, they require no maintenance during the course of their almost indefinite life. In operation, the heat they generate is negligible and consequently they may be fitted into cubicles of smaller dimensions than would be acceptable for equivalent types of control. The standard range is comprised of models rated at 1 KVA, 3 KVA, 5 KVA, 8 KVA and 10 KVA and designs for other powers can be readily made available.

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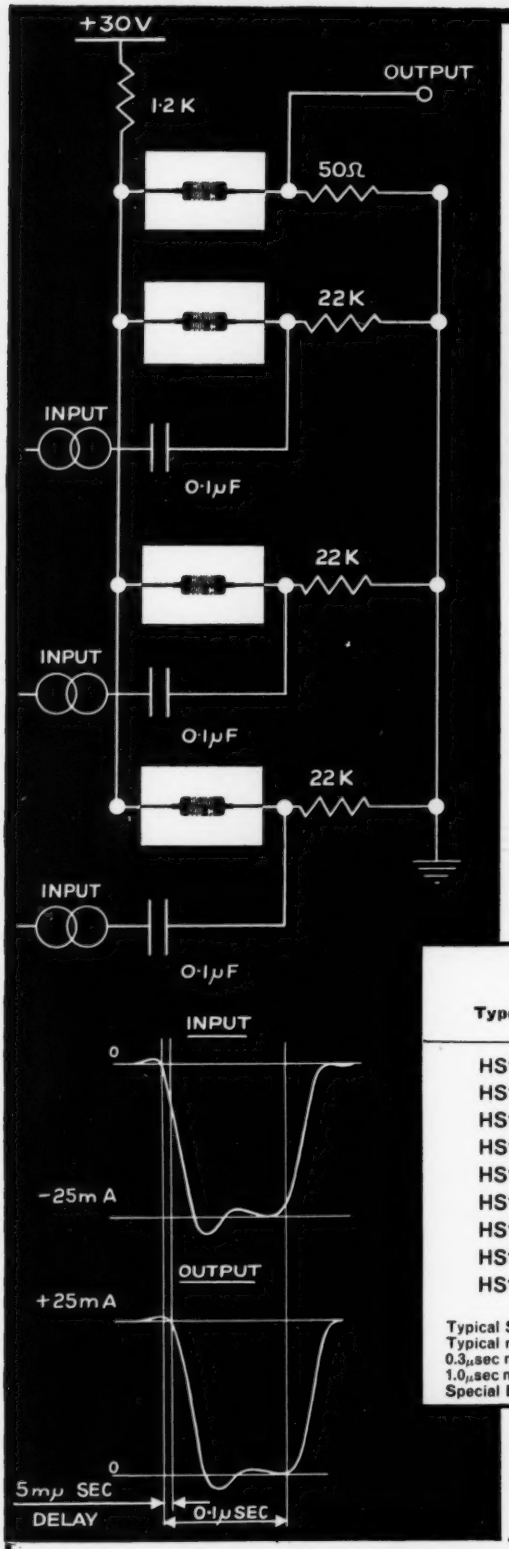

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Type No.	Continuous Ratings 25°C		Characteristics 25°C	
	Max. Rated P.I.V. (Volts)	Max. Forward Current	Min. Forward Current at 1.5V	Max. Reverse Current at P.I.V.
HS1101	150	80 mA	30 mA	1 μA
HS1102	100	80 mA	30 mA	1 μA
HS1103	50	80 mA	30 mA	1 μA
HS1104	150	60 mA	15 mA	1 μA
HS1105	100	60 mA	15 mA	1 μA
HS1106	50	60 mA	15 mA	1 μA
HS1107	150	40 mA	5 mA	1 μA
HS1108	100	40 mA	5 mA	1 μA
HS1109	50	40 mA	5 mA	1 μA

TEMPERATURE RANGE -65°C TO 150°C

Typical Stored Charge Measurement, 700 pico—coulombs.

Typical recovery time:

0.3μsec measured in JAN256 circuit, to 80 K ohms when switched from I_f 5 mA to V_r—35 volts

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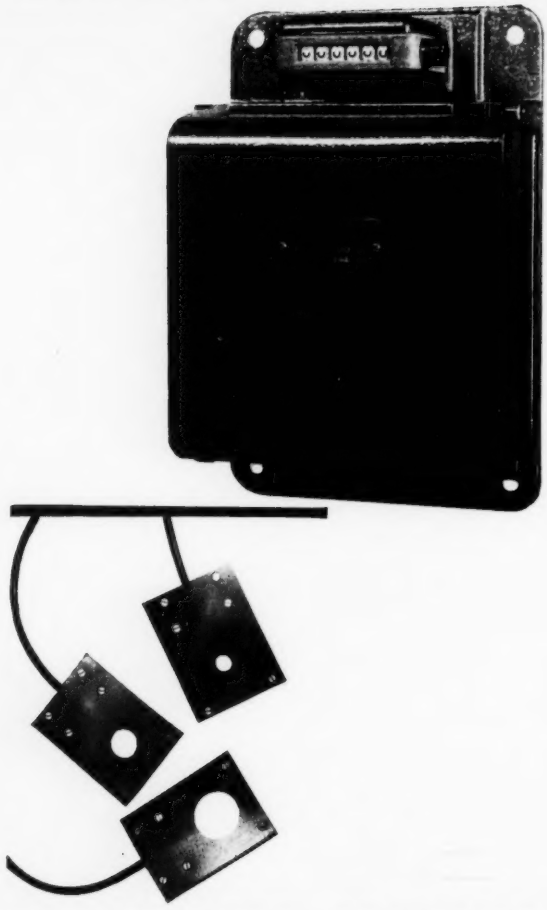

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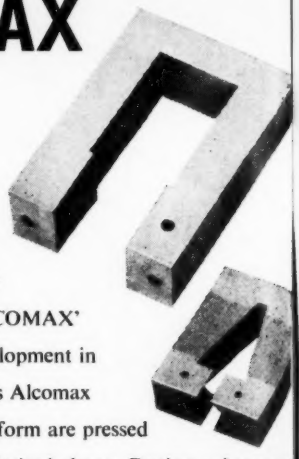
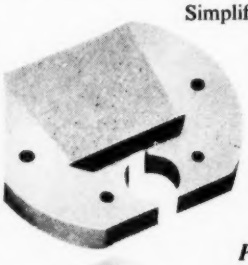
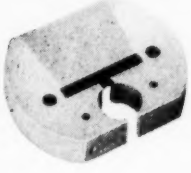
A TECHNIQUE . . .



Powder Metallurgy has made possible the production of these single-unit magnetic circuits which offer many advantages. The 'SINCOMAX' technique is a MUREX development in which a magnet alloy such as Alcomax III, and soft iron in powder form are pressed simultaneously in a die of desired shape. During subsequent sintering, magnet material and iron become alloyed together at the interface to form a single unit of high bond-strength.

Simplified production and the achievement of high standards of performance can be expected when using 'SINCOMAX' magnets. A few of the advantages derived from employing this type of unit are:





Pole tunnels and fixing holes can be machined in the iron section.

The need to grind adjacent magnet and pole faces is eliminated.

Fixing of pole pieces is not necessary.

The absence of air gaps between magnet and pole pieces results in a more efficient magnetic circuit.

A stable bond of great mechanical strength is achieved between magnet and iron sections.

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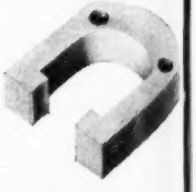

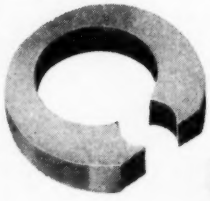

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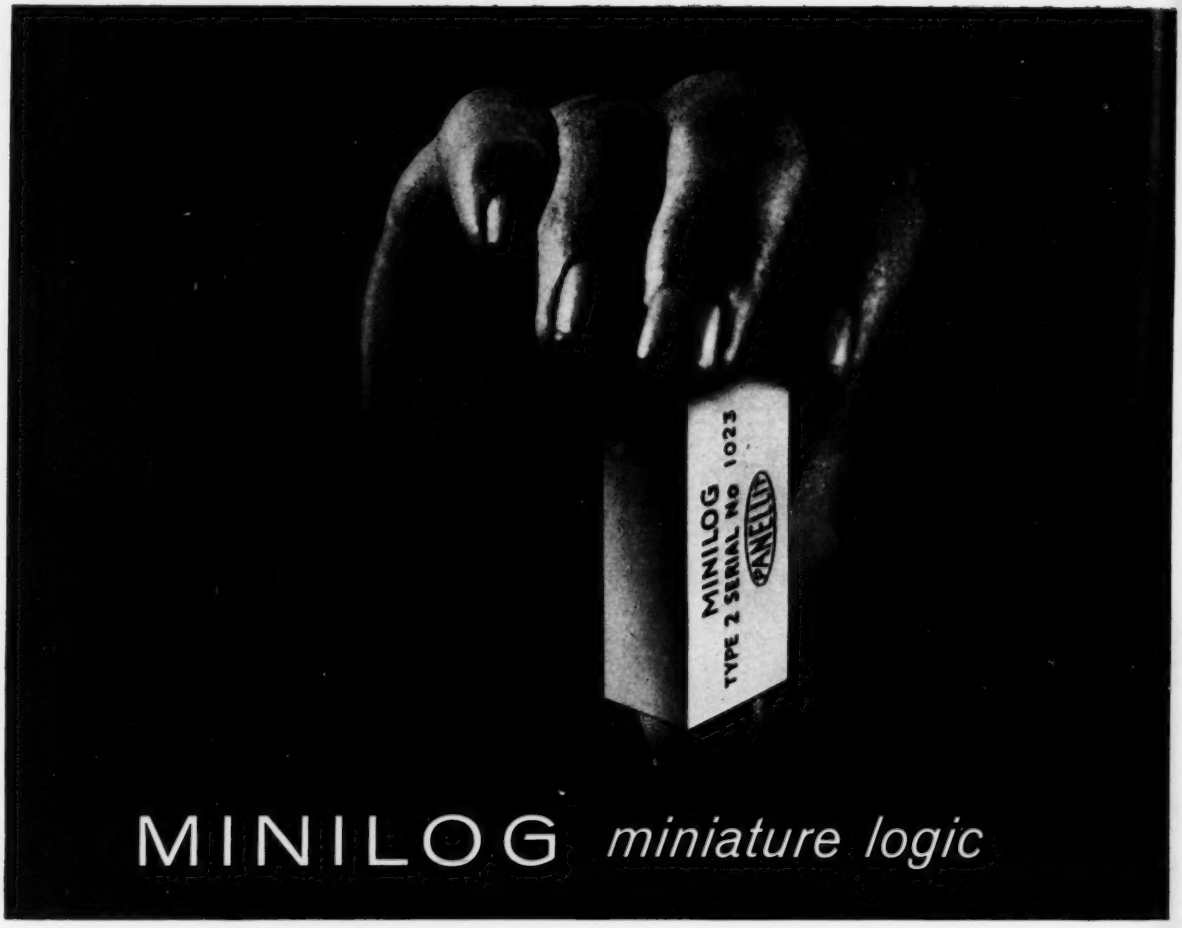

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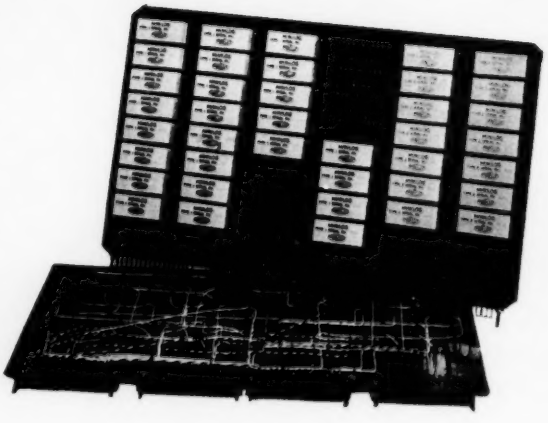

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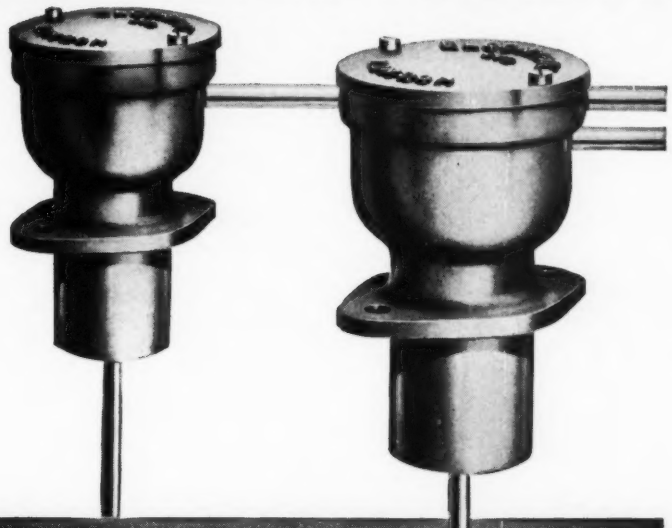

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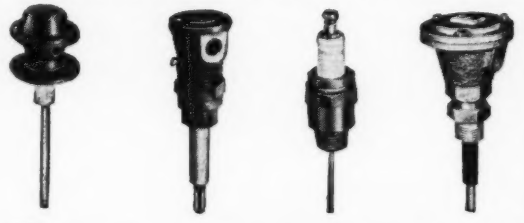

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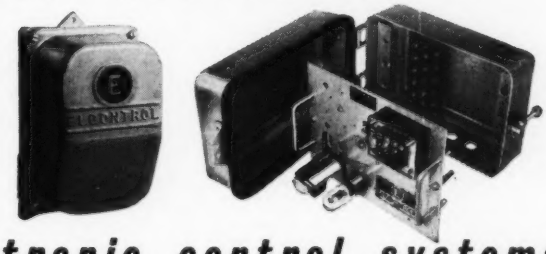

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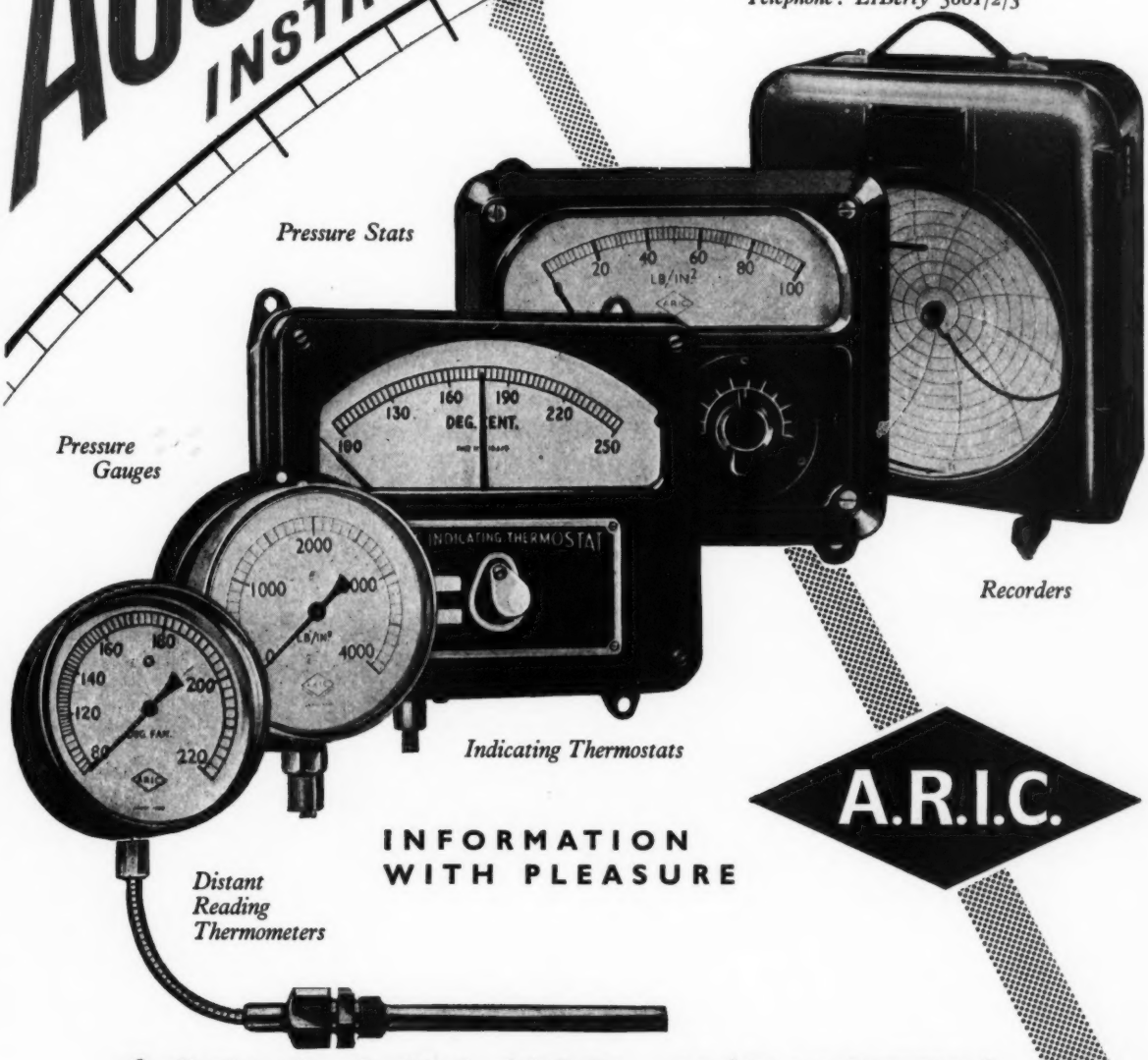

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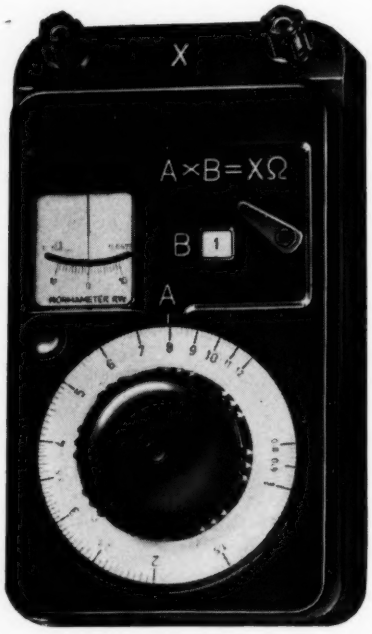

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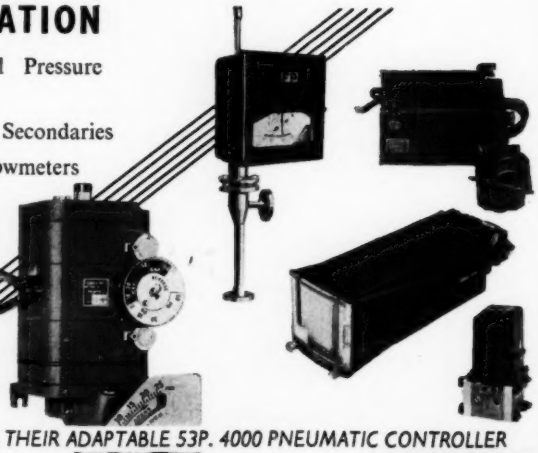

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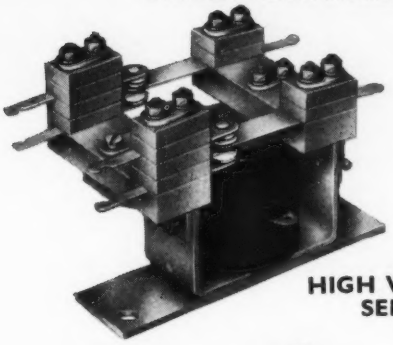

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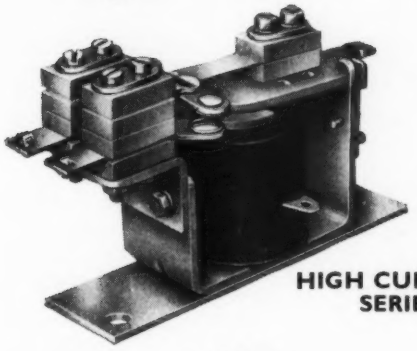

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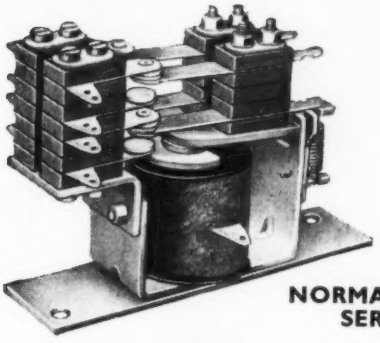

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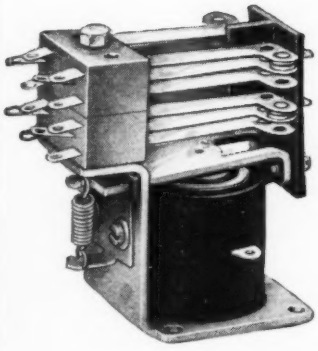

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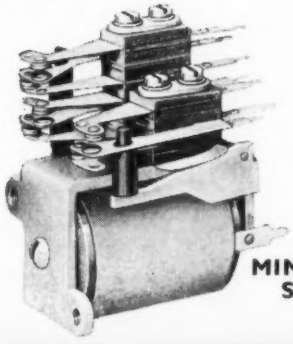

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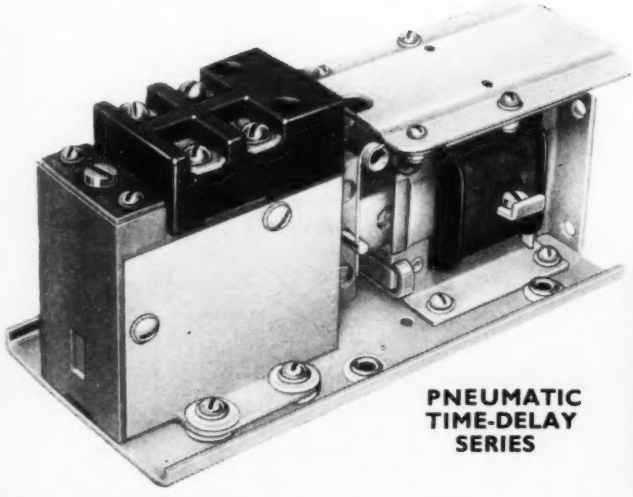

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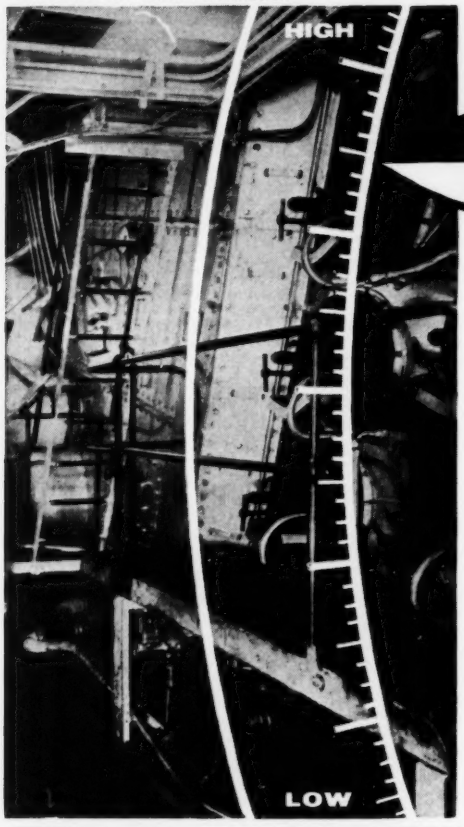

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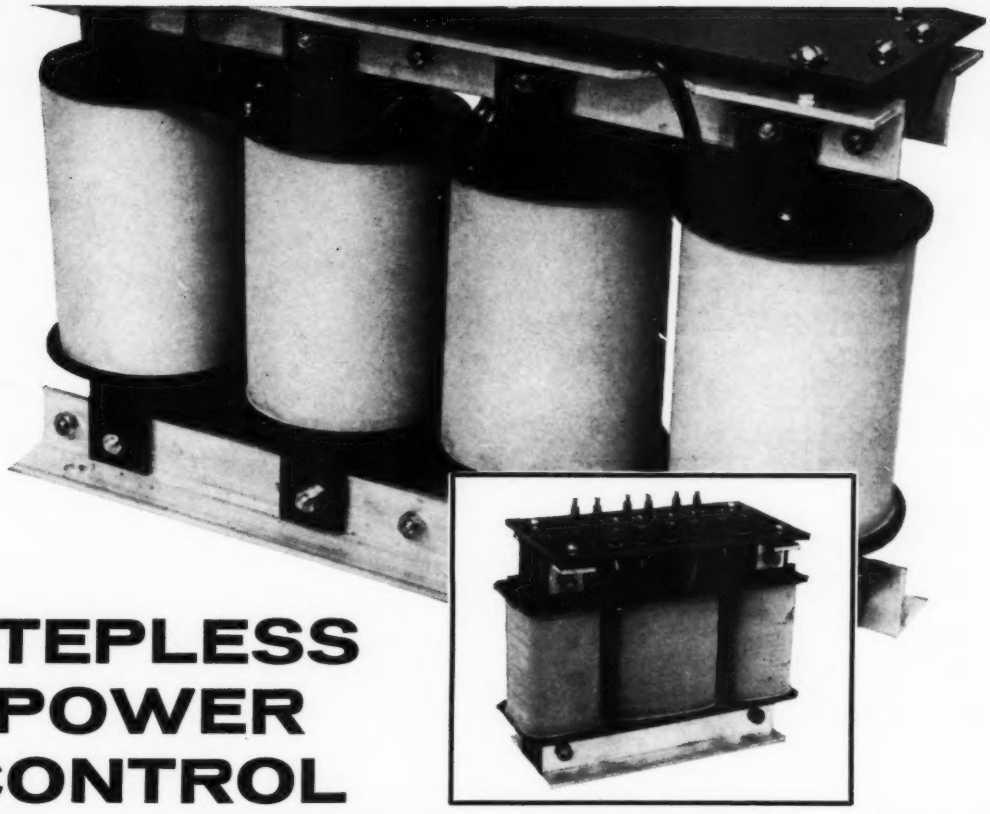

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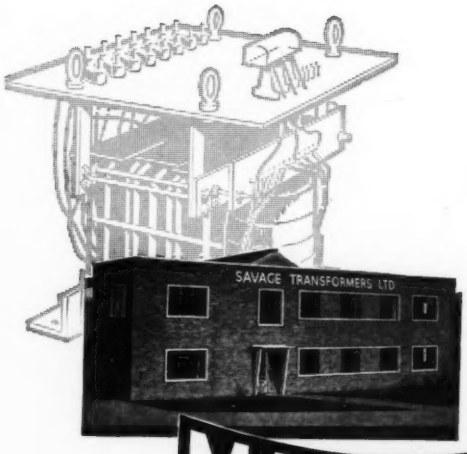

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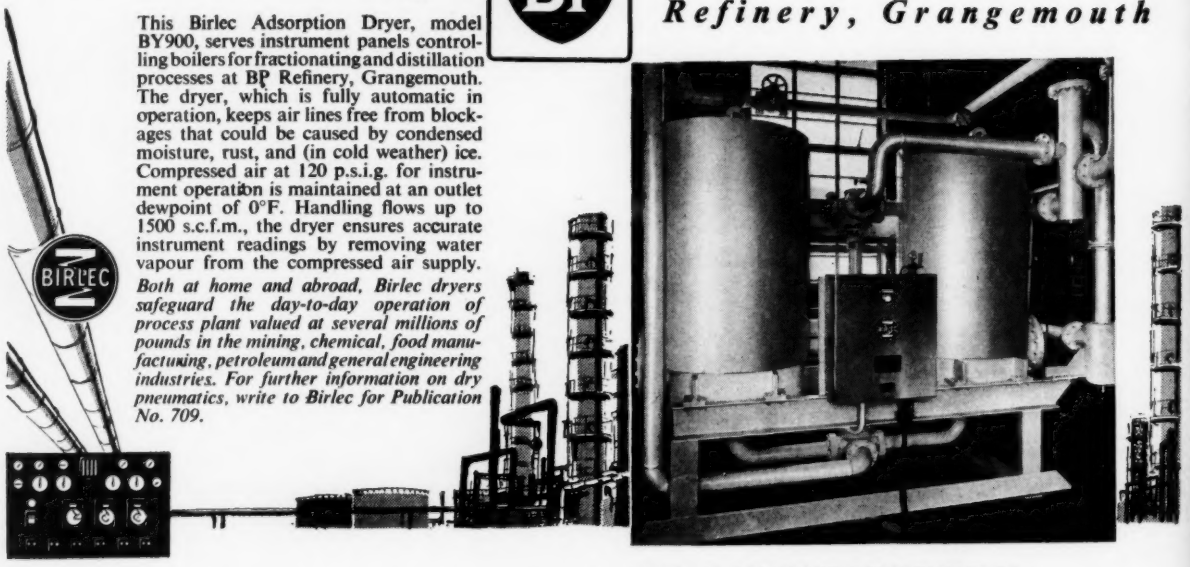

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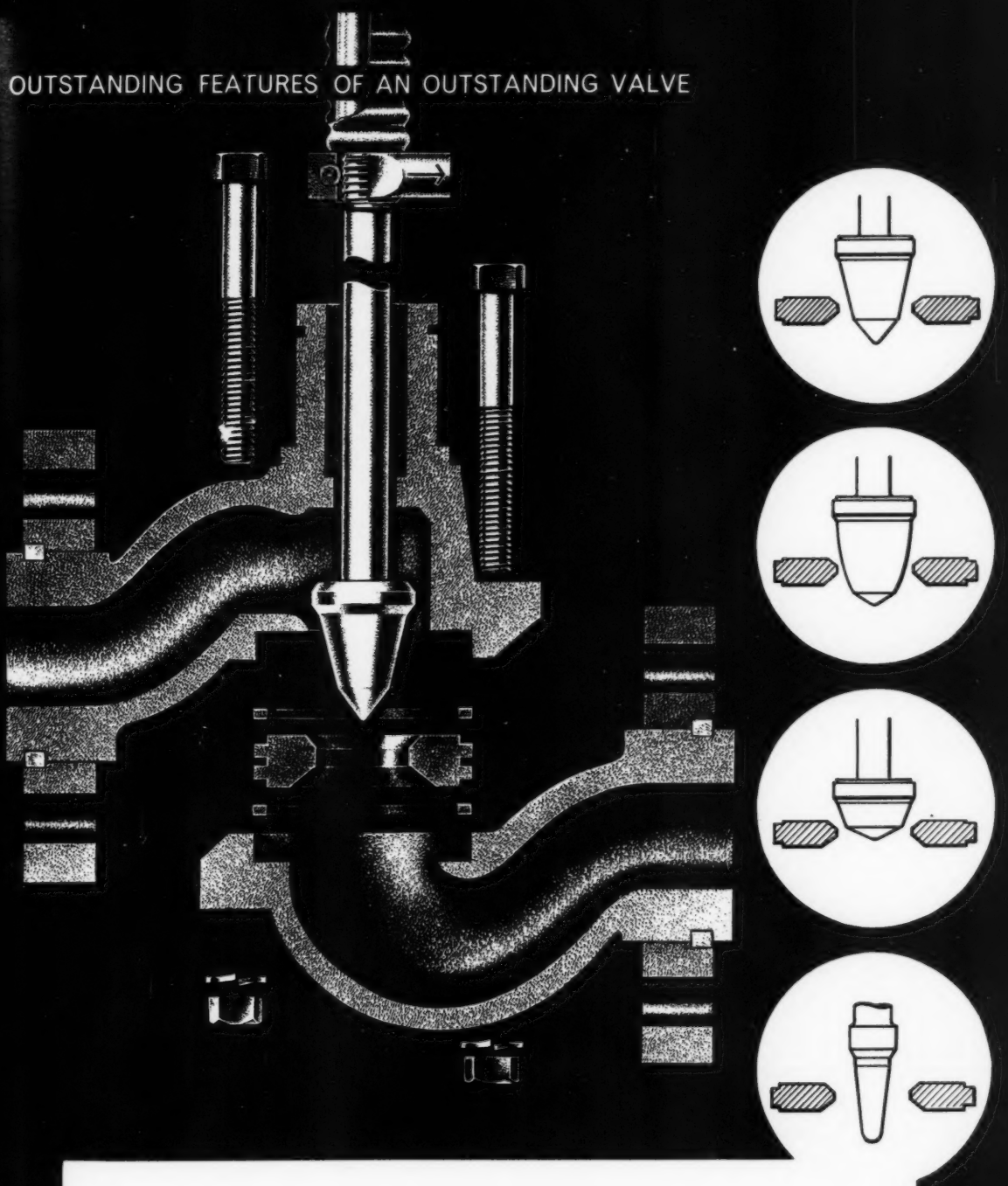

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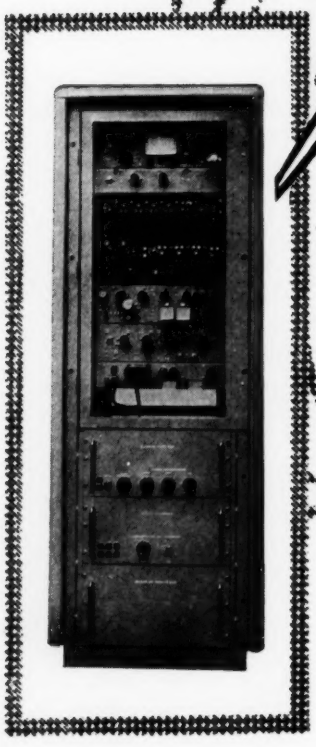

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INSTRUMENT PRACTICE

COMMENTARY

Maintenance Readers will have observed in this issue an article on the organisation of an instrument department in a plant utilising a relatively large number of instruments. This is not a unique situation, for most firms with large instrument installations (for example, over the figure of 200 instruments suggested in the article) have departments where equipment may be tested, repaired and calibrated. Modern requirements for measuring and control systems have necessitated extremely rapid developments and the relatively large amount of attention paid to the operation and application of these developments has tended to obscure the subject of maintenance. Yet the very nature of the newer conceptions can easily raise some major maintenance problems.

As a sub-title to our Survey of New Instruments in this journal we have the phrase: "Electrical – Electronic – Mechanical – Nucleonic – Pneumatic". We consider that these cover broadly the classes of instruments and instrument systems now being manufactured, or likely to be manufactured in the near future, and, hence, the classes with which a maintenance department may have to deal. These classes comprise a wide variety of instruments and a mixture of the various types may easily occur in plants of the future. The shortage of personnel of the right calibre is likely to persist in maintenance as in other parts of the instrument field and some form of " optimisation " of maintenance work is obviously required. How is this going to be accomplished?

The first requirement would obviously be design for reliability. There is little need to stress this point as no British instrument manufacturer would do anything else. The one point in making this statement is that instrument manufacturers use many components and parts in their equipment. Where these are their own products they may control design, manufacture and testing at every stage and ensure efficient operation of the assembled instrument. Where components are purchased from an outside supplier, however, manufacturers receive the finished item, having had no hand in the production. For instruments of the mechanical or pneumatic pattern the majority, if not all, parts may be made by the instrument manufacturer, but in electronic and nucleonic instruments a large number of components will be purchased from component firms. The failure of an instrument in these cases may depend on the failure of a single component and the reliability of these is, therefore, of the utmost importance. This factor has been well considered by component manufacturers, and has been the subject of a number of recent conferences. Some of the failure rates quoted at these meetings have been remarkably low.

Even assuming that the utmost effort has been made in reliability of instrument and component design, however, we must face the fact that a failure may occur in operation. This brings us to the second point: design for serviceability. Easy accessibility is, of course, a major factor here, but an equal, if not more important one, is easy replaceability. This has been well recognised and one has only to look at a modern instrument to see that plug-in units are used in great numbers. It is easy to achieve in electronic instruments, but it has also been achieved in mechanical-pneumatic instruments, a far more difficult task.

With the addition of adequate operating handbooks the manufacturer with the functions of designing for reliability and serviceability has fulfilled his part.

How does one ensure optimisation of maintenance at a plant? By obtaining the right personnel is an obvious statement, but we wonder if all users of instruments give the same thought to the selection of maintenance staff as to instrument engineers and other grades. Yet surely it is well worth it. After this obstacle has been surmounted there is still the problem of training and, with the newer types of instruments appearing, a solution is becoming urgent. The recent White Paper " Better Opportunities in Technical Education " (February issue, page 187) has appeared none too soon and one hopes we shall not meet the situation envisaged by C. L. Parish, Assistant Director of Organic Training, Monsanto Chemical Co., St. Louis plant. He states, " Tomorrow's instruments, if developed upon the same pattern as are today's, will be almost impossible to use unless we change our maintenance system ". (*I.S.A. J.*, January, 1960, page 85.)

Mr. Gordon Watkins

WE REGRET to report the sudden death, at the age of 52, of Mr. Gordon Watkins, a Director of United Trade Press Ltd., publishers of *Instrument Practice*.

Mr. Watkins has been a member of the Company for twenty-five years and was concerned with the development of the entire group of the U.T.P. trade publications.

Mr. Watkins was also a Director of U.T.P. Exhibitions Ltd., and a Director of Tailor & Cutter Ltd., publishers of the *Tailor and Cutter* weekly trade journal.

He leaves a widow, son and daughter.

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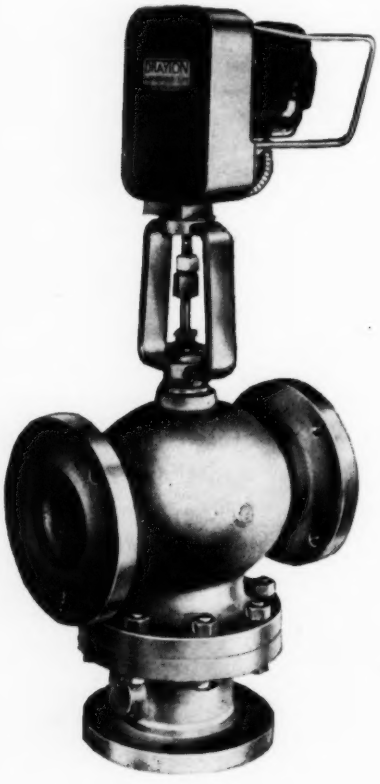

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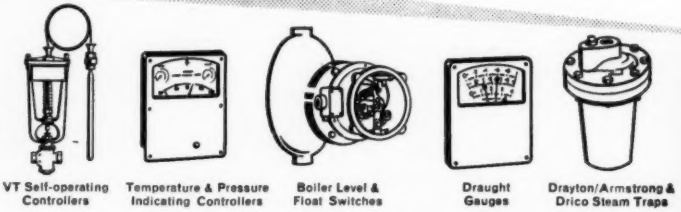

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This new development—one of the most interesting ever made in the precision tube field—raises new problems for both tube producer and tube user. Because defects which previously could not be detected can now be found with ease, the user has to think afresh about the size of defect which he will accept. For if these new techniques have proved anything, it is the fact that the perfect tube does not exist.

Allowable Defects

For certain applications only the smallest defects may be allowable. On one nuclear energy contract, Accles & Pollock have even provided an individual "defect record" with each single tube. This is done by arranging for the testing equipment to provide, in addition to a visual indication for the operator, a pen recorder trace which can be attached to the tube under test as a permanent record.

Less stringent requirements will satisfy most customers, but in every case where these new methods are applied there is a new responsibility on the user to define the size of defect which is acceptable for the particular application for which the tube is intended.

The enormous advantage of these new techniques over former methods is, of course, that they can detect defects which would be impossible to identify by visual inspection and which could result in failure of an instrument under test or in service. The raw material for precision tube-making is generally in the form of hot-worked "hollows" which are subsequently reduced in diameter and thickness by cold-working. Non-metallic inclusions may be present in the original cast of steel, and overlaps and cracks may occur in the initial hot-working of the billet. Such a fault may be minute in comparison with the cross-sectional area of the original hollow, but when the tube has been cold-drawn down to capillary size, that same fault may begin to propagate and represent an alarming percentage of the thickness of the tube wall.

The very nature of the cold-drawing process imposes such severe stresses on the material that such faults are usually revealed in the course of production. But inevitably some remain, unsuspected because they are hidden inside the tube wall, or unseen because of the impossibility of inspecting the bore of long tubes of small diameter.

Such precision tube is the end product for the tube-maker, but it is the raw material for the instrument maker, who may spend a great deal of time and labour converting it to its ultimate use before an unsuspected defect reveals itself. The new techniques of non-destructive testing, therefore, should result in tube which reduces scrap in its most expensive form—the

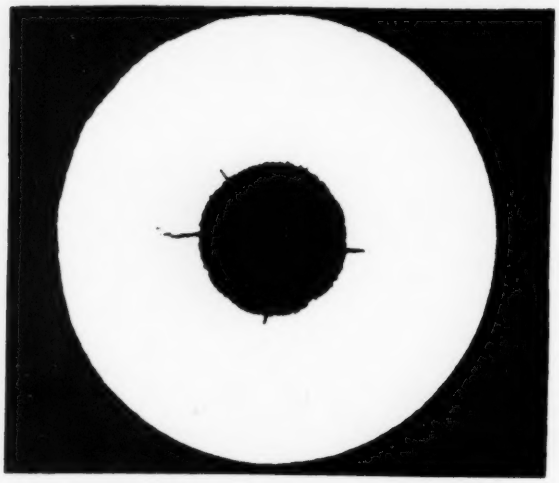


Fig. 1. *Micrograph showing cracks propagating from the bore surface of a mild steel tube*

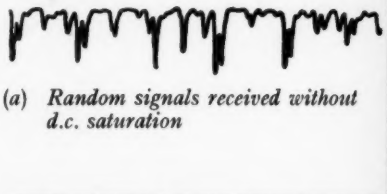
finished product—and also offers a greater guarantee of long and trouble-free service.

Eddy Current Testing

The new developments are the result of several years' work by a special non-destructive testing section set up at the Accles & Pollock works. Apart from the fairly conventional methods of magnetic crack detection and dye penetrant tests, the two fields that have been developed are those employing eddy currents and ultrasonics. Broadly speaking, ultrasonics are used to find mid-wall defects in addition to surface defects in larger tubes of heavier gauge. Tubes in the ranges used by most instrument makers are more readily tested by eddy current techniques, which have been applied down to hypodermic needle sizes. Some understanding of these eddy current techniques, therefore, may help instrument makers to take better advantage of this new development.

Early trials by the Accles & Pollock non-destructive testing section soon established that conventional concentric coil systems were unable to locate small defects in tubes in the cold-worked condition owing to rapid changes in conductivity and permeability along the tube length. This restriction applied not only to mild steel, but to both martensitic and austenitic stainless steels, and even annealed tubes were found to be

Fig. 2. *Recording traces of* 18% *Cr*, 8% *Ni*, *stainless steel tube* 0·032 *in. o.d.* × 0·006 *in. thick.* *Excitation frequency* 100 *kc/s*



(*a*) *Random signals received without d.c. saturation*

(*b*) *Result obtained with d.c. saturation*

Fig. 3. *Recording of a test made on stainless steel tube* 0·531 *in. o.d.* × 16 *s.w.g. Excitation frequency* 10 *kc/s*

(*a*) 0·040 *in. diameter hole*
(*b*) 0·063 *in. diameter hole*
(*c*) *Plug chatter*

seriously affected by subsequent polishing or straightening. The variations in conductivity and permeability produced signals on the test equipment comparable in magnitude to those given by gross defects. Testing immediately after annealing reduced these unwanted signals, but ambiguous results still existed with the result that a certain percentage of sound material was inevitably rejected.

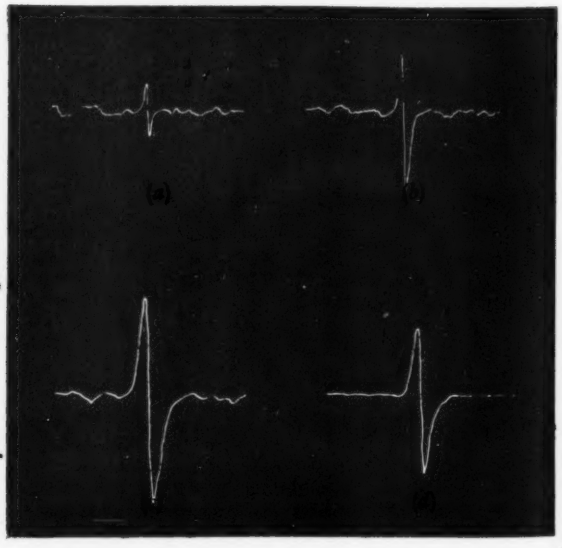
The practical problem was to reduce—and, if possible, eliminate—these random variations in permeability caused through the alterations to the metallurgical structure of the material through work-hardening. At the same time there was a more theoretical problem of trying to obtain the maximum depth of penetration. Fortunately, one solution answered both problems.

D.C. Saturation Technique

When a metallic object is placed in the region of a uniform alternating field, the value of the eddy currents induced in the object is greatest at the surface. The

Fig. 4. *Oscillograms showing signals given by artificial defects in zirconium alloy tubing using a surface probe. Tube size* 0·600 *in. o.d.* × 0·018 *in. thick*

(*a*) *Slot* 0·0015 *in. deep* × 0·005 *in. wide* × $\frac{1}{2}$ *in. long*
(*b*) *Slot* 0·0025 *in. deep* × 0·005 *in. wide* × $\frac{1}{2}$ *in. long*
(*c*) 0·015 *in. dia. hole*
(*d*) 0·025 *in. dia. hole* ($\frac{1}{4}$ *sensitivity*)



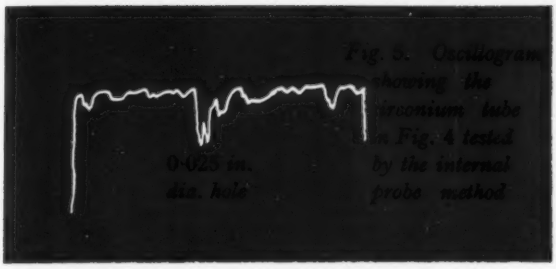


Fig. 5. Oscillogram showing the zirconium tube in Fig. 4 tested by the internal probe method

0·025 in. dia. hole

value of these currents falls off approximately exponentially with depth from the surface, and one of the factors controlling this depth of penetration is the magnetic permeability of the material. If, therefore, the incremental magnetic permeability of the material being examined could be reduced at the point of inspection to unity, not only would the random variations be eliminated, but the depth of penetration, in the case of mild steel, would be increased by more than twenty times.

Further research in this direction was undertaken by the Accles & Pollock team, working with the staff of the Tube Investments Technological Centre at Walsall, and techniques for d.c. saturation were eventually evolved. Units were made up capable of testing tubes ranging from $3\frac{1}{2}$ in. down to $\frac{1}{64}$ in. in diameter, and their success may be judged from the micrograph (Fig. 1) showing cracks propagating from the bore surface of a mild steel tube, 0·050 in. diameter × 0·015 in. internal diameter, which were located using d.c. saturation techniques. Approximately 15,000 feet of this tubing was tested, with excellent results.

The recording trace (Fig. 2) again shows the importance of saturation in virtually eliminating random fluctuations caused by the varying magnetic properties along the length of cold-worked tube. The material in this instance is 18/8 type stainless steel, and the sample chosen was of perfectly acceptable quality. The top trace shows the random signals received without d.c. saturation, and the lower trace the result achieved when those unwanted variations are removed—a reasonably straight line which could make any defect immediately apparent.

The recorder trace is made on graph paper, and in order to set standards, artificial defects can be created in a test tube by drilling holes or machining slots. The amplitude of the signal recorded on the trace by these defects of known size can then be used to provide an approximation of the size of unknown defects.

Testing Probes

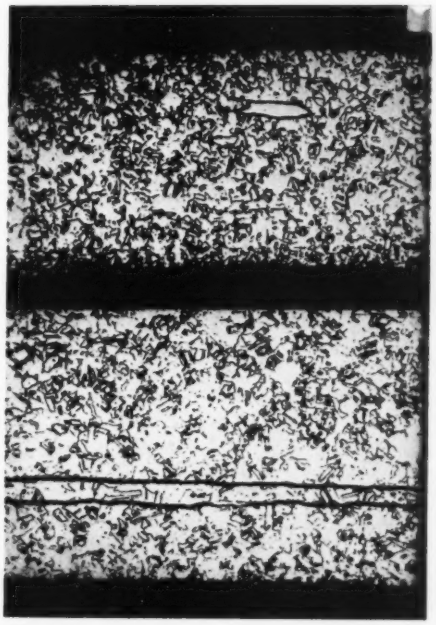
A concentric search coil through which the tubes to be tested can be passed is obviously the simplest method around which to build, but it does have limitations and more sophisticated techniques have been evolved. The external concentric coil, for instance, is not very sensitive to small bore defects in thick-walled pressure tubes, and may fail miserably on tubes having cooling fins on the outside. In these cases an internal probe can be used much more successfully, and a range of such probes down to $\frac{3}{8}$ in. diameter has been produced by the Accles & Pollock non-destructive testing section staff.

The concentric coil is also very sensitive to very small changes in tube dimensions. A relatively mild case of "plug chatter", which can easily occur in manufacture, and which might be quite acceptable for many applications, can produce signals of considerably greater amplitude than a small hole which would mean instant rejection. An example of this exaggerated effect is shown in Fig. 3, a recording of a test made on a length of stainless steel tube, 0·531 in. outside diameter × 16 s.w.g.

This limitation can be overcome by using a surface probe scanning the tube in a helical fashion—necessarily a more complex operation, but, as Fig. 4 shows, giving extremely high resolution. Six thousand zirconium tubes have been tested by Accles & Pollock using this method, with very satisfactory results. Fig. 4 shows the oscillograms recorded by using a surface probe on a zirconium tube, 0·600 in. outside diameter × 0·018 in. wall thickness, in which artificial defects had been created. For comparison, Fig. 5 shows the same tube tested by the internal probe method, when only the 0·025 in. diameter hole was detectable.

The surface probe technique, using helical "scanning", also has the advantage of being much more sensitive to continuous longitudinal cracks or other defects which could possibly be missed when the search coil travels along the same axis as the tube, since a constant unvarying deflection would be recorded. One very interesting instance which showed the high sensitivity of the surface probe in this direction was with the tube illustrated in Fig. 6, 0·360 in. inside diameter × 0·015 in. wall thickness, made from a vacuum melted stainless alloy, 20% Cr, 25% Ni, niobium stabilised. A defect was detected in the form of a metallic segregation 0·005 in. wide × 0·001 in. thick,

Fig. 6. Defect detected in tube wall



(a) Cross-section

(b) Longitudinal section

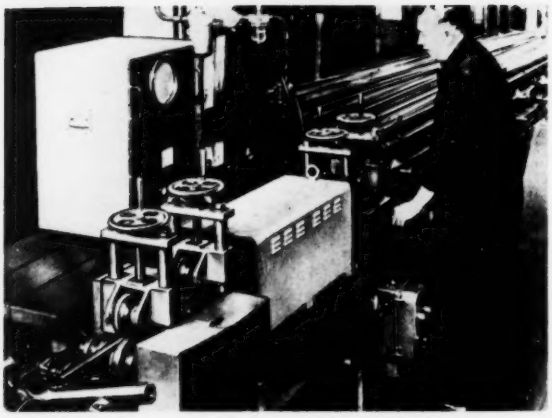


Fig. 7. Concentric coil testing unit installed in the main warehouse

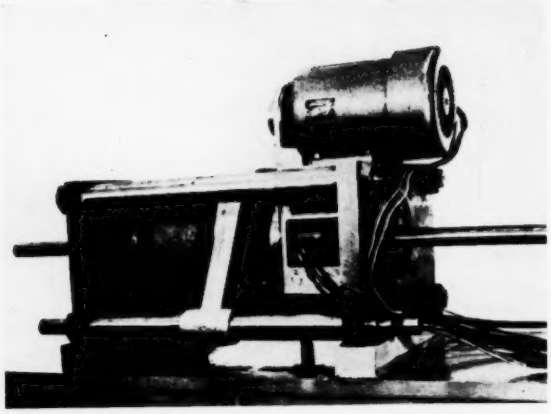


Fig. 8. A unit designed for production testing using surface probe techniques

0·004 in. below the surface, having a length of several feet. Fig. 6 shows a cross-section and longitudinal section of the tube wall at this point and illustrates the uniform shape of the defect along the length of the tube, which would have made it extremely difficult to detect with a concentric coil system. With a surface probe, the amplitude of the defect signal was several times full-scale deflection at the normal testing sensitivity used. The segregation was found to be magnetic and its analysis was determined by micro-analyser as 37% Ni, 62% Fe and 0·2% Cr.

This is a most striking example of the location of a defect which could never have been even suspected without the use of these new techniques.

Production Testing

Evolving new techniques in the laboratory is one problem. Applying them under production conditions is another and almost equally difficult task. In tackling that second task, Accles & Pollock have paid particular attention not only to devising robust equipment able to operate reliably under tube mill conditions, but also to the associated tube handling equipment, which has been designed to enable the operator to give undistracted attention to the defect-indicating screen. Many millions of feet of tube have been tested on the concentric coil installation shown in Fig. 7, which is installed in the company's main warehouse, and that experience has shown the importance of a carefully planned, fully automatic testing set-up.

Similar care has gone into the planning and manufacture of the device shown in Fig. 8, by T.I. Technological Centre, Walsall. This has been designed to apply surface probe techniques on a production basis. With rotating speeds of up to 2,000 rev/min., a throughput of 40 feet of tube per minute can be attained—well below the concentric coil installation figure, but still acceptable in view of the higher sensitivity necessary for certain applications.

Another installation will shortly be erected for dealing with tubing in the hypodermic needle ranges on a production basis.

Technical Writing Awards

THE winners of the 25-guinea premiums awarded by the radio and electronics industry for six technical articles published in 1960 are announced by the Electronics Engineering Association and the Radio Industry Council, the sponsors of the scheme.

Sir Harold Bishop, Director of Engineering, B.B.C., presented the awards at a special luncheon at the Café Royal, London, on 25th April.

The 1960 prize-winners, not in order of merit, are:—

A. E. CRAWFORD, M.Brit.I.R.E., S.M.I.R.E., "Piezo-electric Voltage Transformers"—*Wireless World*, October.

G. L. GRISDALE, B.Sc., Ph.D., and D. A. PAYNTER, A.M.I.E.E., A.M.Brit.I.R.E., "A Tropospheric Scatter Link over a 200-mile Path"—*Point-to-Point Telecommunications*, October.

D. L. SWALE, "Integrated Electro-mechanical Design as Applied to Electronic Equipment"—*British Communications and Electronics*, March.

C. M. CADE, M.Brit.I.R.E., Sen.M.I.R.E., M.Inst.Nav., "Infra-red Radar Surveillance and Communications"—*British Communications and Electronics*, June-July.

E. N. ROWLANDS and H. S. WOLFF, "The Radio Pill"—*British Communications and Electronics*, August.

P. L. OWEN, M. F. PARTRIDGE, M.A., and T. R. H. SIZER, A.M.I.E.E., "The Differential Analyser and its Realisation in Digital Form"—*Electronic Engineering*, October.

Under the chairmanship of Mr. H. E. F. Taylor, who succeeded the late Air Marshal Sir Raymund G. Hart, the panel of judges comprised Professor H. E. M. Barlow, Mr. B. C. Brookes, Mr. A. H. Cooper, Mr. F. Jeffrey, Mr. G. Reeves and Dr. R. C. G. Williams.

The awards scheme is likely to be extended and revised for 1961.

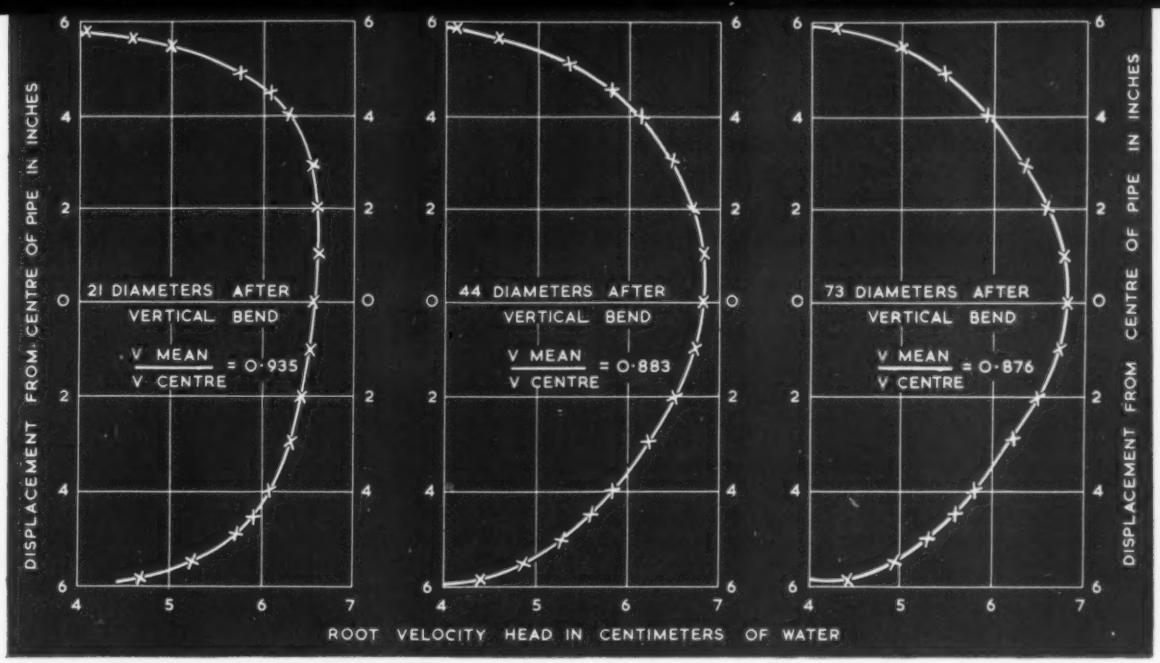

DISPLACEMENT FROM CENTRE OF PIPE IN INCHES
21 DIAMETERS AFTER VERTICAL BEND
V MEAN / V CENTRE = 0·935
44 DIAMETERS AFTER VERTICAL BEND
V MEAN / V CENTRE = 0·883
73 DIAMETERS AFTER VERTICAL BEND
V MEAN / V CENTRE = 0·876
DISPLACEMENT FROM CENTRE OF PIPE IN INCHES
ROOT VELOCITY HEAD IN CENTIMETERS OF WATER

Fig. 1. *Velocity profiles in* 12 *in. pipe*
$\lambda = 0{\cdot}017 \quad R_D = 650{\cdot}000$

The Influence of Pipe Conditions on Flow Measurement

By R. G. WEST
Head of the Fluid Dynamics Laboratory
Electroflo Meters Co., Ltd.

Introduction

AT the end of the previous article (April, pp. 440-446) reference was made to a programme of tests on four primary devices under similar states of pipe roughness variation, bad upstream conditions and so on.

They were followed by tests on the effect of roughness of the internal surfaces of the devices themselves. These in turn were followed by the pressure loss and poor location tests. A full description of the plant used for these tests is probably unnecessary, since the Fluid Dynamics Laboratory of Electroflo Meters Company Limited is very well known and has been described many times. However, some general comments on test arrangements and particularly those used for the work under discussion are appropriate.†

Author's Note: † I thought that it might be more interesting here to describe the thoughts behind the choice of test installation conditions rather than the usual formal description of them. Inevitably in giving reasons or explanations some overlap between this and the first section of the article must occur, but any repetition of facts is nevertheless made with different emphasis.

In the past, little attention has been given to the basic requirements of a test installation. It had been thought sufficient to ensure that the test pipe ran full, was straight and of anything from ten to twenty pipe diameters in length.

Such an attitude failed to recognise the importance of pipe wall roughness and the need to allow velocity distribution to develop fully. The velocity profiles in Fig. 1 show how the shape of the curve changes over eighty diameters of 12 in. diameter commercially smooth pipe (friction coefficient $\lambda = 0{\cdot}017$).

Velocity Profiles

A convenient measure of the change is given by the ratio V_M/V_C where V_M = mean velocity,
V_C = velocity at centre of pipe.

Values of this ratio are also given on Fig. 1 and emphasise the extent to which the central velocity core is changed with increase in the length of upstream pipe.

It is usual to quote the values in the range $0{\cdot}7 < V_M/V_C < 0{\cdot}88$, but in fact only the lower values in this range are very often found to apply to past work. This is a significant criterion; it is a cause of variation in

the values of the discharge coefficient of any measuring device.

As early as 1911, Stanton[1] showed that both pipe roughness and pipe length affected the values of V_M/V_c to an appreciable extent: in his tests smooth pipes gave values $0{\cdot}835 < V_M/V_c < 0{\cdot}848$ in contrast to rough pipe values in the range $0{\cdot}797 < V_M/V_c < 0{\cdot}799$. The test sections of 4·9 cm and 7·40 cm diameter smooth pipes were nine metres long, while those of the 7·35 cm and 5·08 cm diameter rough pipes were five metres long. Subsequently it has been established that increases in V_M/V_c are, to an important degree, due to the greater length of pipe used.

Variation of Discharge Coefficient with Roughness and Pipe Length

To underline this point Fig. 2 shows the variation in the discharge coefficient of a thin plate orifice with pipe length and roughness. As is to be expected, the variations are most significant at higher values of area ratio m.

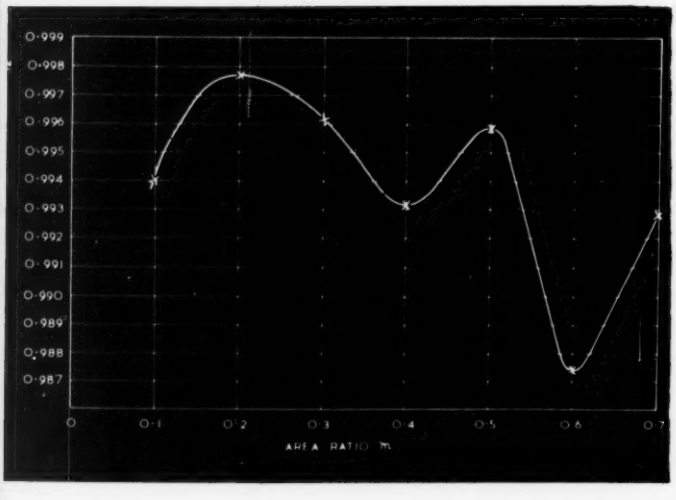
It is now apparent that test lengths of not less than 60 pipe diameters must be used in future if any attempt be made to correlate coefficient data.

Equally important and, of course, to some extent inter-related to the preceding remarks, is that the diameter of the test pipe shall be suitable.

Here again, past practice has been confusing; it was common practice to use 4 in. and 6 in. diameter pipes for test work, but the importance of pipe roughness was not then understood with the result that it was considered sufficient to treat pipe diameter as a unifying feature, instead of one that takes account of the relation between pipe diameter and roughness.

More recently, the ratio D/k (where D = pipe diameter, k = pipe wall roughness height) has been advocated as a convenient and reliable means of specifying the condition of a test pipe.

Fig. 2. Variation of discharge coefficient value with pipe length and diameter
8in. pipe **20** *diameters long* $\lambda = 0{\cdot}017$
12in. pipe **75** *diameters long* $\lambda = 0{\cdot}017$



The method of advocacy has been by the use of tests on artificially roughened pipes and the effect on the discharge coefficient of a thin plate orifice. Although artificial roughness has been used in connection with pipe friction theory by Nikuradse[2] and others, and has yielded valuable information, the fact remains that it can be misleading.

This is particularly so when attempts are made to establish coefficient data using this technique. The reason is probably that velocity profile and pressure gradient before an orifice are dependent upon patterns of roughness.

Recently a paper by Clark and Stephens[3] has underlined the essential uncertainties which exist as a result of relying too much upon tests using regular patterns of artificial roughness. In this paper, in spite of exaggerated conditions of roughness and the fact that both Reynolds number and the friction factor λ have been ignored, it is clear that artificial roughness has marked effects on coefficient values quite unlike those met with in pipes which are or have become naturally rough.

Even more recently Morris[4] has shown that axial spacing or grouping of roughness elements may be as, or more, important as roughness height.

It seems futile to persist in this method of correlation alone: instead, a firm intention to include or add the pipe friction coefficient and/or boundary layer displacement thickness could lead to a much better effort of correlation in future. The obvious advantages of these terms is that they involve, directly or indirectly, pipe length which incorporates roughness pattern variation in height and length. They do not rely upon the extremely limited assessment of roughness height which even the best roughness meter can make due to the limited travel of the stylus and to the fact that only the pipe wall at the mouth can be traversed.

Eventually, it may be possible to associate accurately the values of λ and D/k with coefficient of discharge. The information at present available needs to be verified and can only be extended by the accumulation of test results, rather than by isolated investigations.

Neither pipe length and velocity profile nor the pipe roughness/diameter ratio can serve any useful purpose in analysis unless the dynamic conditions of test are satisfactory.' It is usual to rely on Reynolds number and, to a lesser extent, on Mach number as a guide to the nature of the flow régime in the pipe.

The application of these criteria must be related to conditions in the pipe and in the throat or vena contracta of the measuring device.

It is, therefore, necessary to read the remarks above concerning the importance of velocity profile and roughness against a background of flow régime characteristics.

Reynolds Number Influence

A Reynolds number value R_D* of 50,000 indicates that the structure of flow, with particular reference to boundary layer development, is immature. The influence of viscous forces, which diminishes after the main transition from laminar to turbulent flow and which

*R_D indicates pipe Reynolds number and R_d throat or orifice Reynolds number.

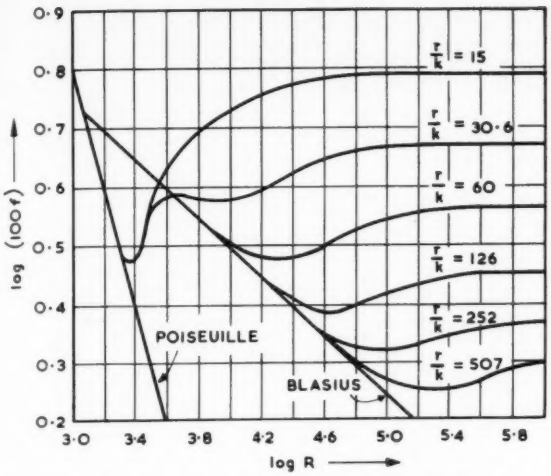


Fig. 3. Friction coefficient f as a function of the Reynolds number R for various relative roughnesses r/k (Nikuradse)

under some conditions occurs at $R_D = 2{,}300$ approximately, is still apparent.

In more exact terms this means that the laminar nature of viscosity-dominated flow which is gradually destroyed by turbulent instability is confined to the outer slower moving layers of fluid near the pipe wall. It can be visualised as a thin walled tube in contact with the pipe wall and through which the truly turbulent flow passes.

As Reynolds number increases in value, so this tube becomes thinner; whether it ever vanishes completely is a matter of conjecture.

There is evidence to suggest that even at very high Reynolds numbers some vestige of this laminar sublayer, as it is called, still remains and that only a major part—not all—of the boundary layer becomes turbulent.

It is clear that the laminar boundary layer thickness relative to wall roughness is a major controlling influence on velocity profile shape and shows the importance of the D/k ratio. If, for example, wall roughness is slight, and its height is less than the laminar layer thickness, and if both are small compared to the pipe diameter, then the roughness can be expected to have little effect on the development of the velocity profile. The converse is apparent without need of detailed explanation except to point out that a change in pipe size in relation to a constant roughness height is synonymous with a change in roughness height in a particular pipe size.

Either method of approach involves changes to the Reynolds number both of the boundary layer and pipe.

It is because of this laminar boundary layer decay and associated matters that more attention must be paid to the dynamic conditions of test as represented primarily by Reynolds number. For one thing, friction coefficient data is dependent up to a point upon Reynolds number. It is common practice to express the friction coefficient in terms of both Reynolds number and D/k and it can be seen that for any given value of D/k the friction coefficient eventually becomes independent of Reynolds number at a value approximately $R_d = 150{,}000$ as shown in Fig. 3. In the second place most primary elements for use in closed conduits with the exception of the Pitot tube are sensitive to Reynolds number influence. In fact the "characteristics" of these elements are really the extent to which they are influenced by Reynolds number under given conditions of installation roughness and pipe size.

It therefore follows that in any comparison of a number of primary elements it must be decided where, in the Reynolds number range, the tests of comparison should be made.

Obviously, test data must be independent of friction coefficient variation which means in effect that the pipe Reynolds number must be at least 200,000. But is this a sufficient minimum?

It has been usual to relate discharge coefficient values to values of Reynolds number based on throat, orifice or vena contracta diameter. Of late it has been necessary, apparently, to mask certain deficiencies of performance data by relating the discharge coefficient to pipe Reynolds number.

Constancy Limit

Tables 1, 2, 3, given here, explain the implications of this change in practice:

TABLE 1

	$R_D = 100{,}000$ Constancy Limit	$R_D = 300{,}000$ Constancy Limit	$R_D = 500{,}000$ Constancy Limit
m	Equivalent R_d	Equivalent R_d	Equivalent R_d
0·1	316,160	948,000	1,581,000
0·2	223,560	671,000	1,118,000
0·3	182,550	548,000	912,700
0·4	158,100	474,000	791,000
0·5	141,420	424,000	707,000
0·6	129,030	387,000	645,200
0·7	119,530	359,000	598,000

TABLE 2

Pipe Diameter (in.)	Velocity ft/sec.	Friction Loss per ft (in. w.g.)	Constancy Limit
4	4·21	0·148	
6	2·80	0·044	
10	1·68	0·009	$R_D = 100{,}000$
15	1·12	0·003	
24	0·70	0·0007	
4	12·63	1·339	
6	8·40	0·394	
10	5·04	0·085	$R_D = 300{,}000$
15	3·36	0·025	
24	2·10	0·006	
4	21·05	3·720	
6	14·00	1·100	
10	8·40	0·237	$R_D = 500{,}000$
15	5·60	0·070	
24	3·50	0·017	

TABLE 3

These represent a maximum flow condition for the three constancy limits, assuming a normal metering range of 10 : 1

Pipe Diameter (in.)	Velocity (ft/sec.)	Friction Loss per ft (in. w.g.)	Constancy Limit
4	42·1	14·880	
6	28·0	4·382	
10	16·8	0·947	R_D = 1,000,000
15	11·2	0·281	
24	7·0	0·069	
4	126·3	133·880	
6	84·0	39·440	
10	50·4	8·522	R_D = 3,000,000
15	33·6	3·524	
24	21·0	0·616	
4	210·5	370·040	
6	140·0	109·560	
10	84·0	23·675	R_D = 5,000,000
15	56·0	7·012	
24	35·0	1·712	

R_D = Pipe Reynolds number
R_d = Throat or orifice Reynolds number
m = Area ratio = $\left(\frac{d}{D}\right)^2$

This data is given for water at 60°F. Absolute viscosity (poises) = 0·013; density = 62·354 lb/ft³. Friction coefficient (assumed) = λ = 0·015. Friction losses evaluated using Darcy formula.

Most primary elements have coefficient values which are constant (i.e., substantially independent of Reynolds number) above a certain value R_d = 200,000. Such values, generally referred to throat diameter are commonly described as the "constancy limit".

Table 1 shows that a device which has a constancy limit equal to a pipe Reynolds number > 500,000 is more sensitive to Reynolds number influence than the standard devices.

A hypothetical case is used in the preparation of Fig. 4 to illustrate this point. Constancy of coefficient is essential if instrumentation based on the law $Q \propto h^{0.5}$ is to be simple. A variable coefficient means that the indices applicable to h will vary with rate of flow.

Furthermore, Tables 2 and 3 underline the economics involved if a device with a Reynolds number constancy limit based on pipe diameter R_D = 300,000 is used for measurement.

Since this is a lower limit, the velocities and friction losses given in Table 2 are also minima; the maxima, assuming the usual metering range of 10 : 1, are given in Table 3. All of which means that care must be taken in interpreting coefficient data !

A large proportion of normal instrumentation occurs in the range 70,000 < R_d < 1,000,000 and, therefore, any device whose coefficient is variable in this range will cause error if constancy is assumed. If the hypothetical device, whose coefficients are shown in Fig. 4, were used in this way, then for a device having m = 0·4 a measurement error of 5% approximately results at 1/8th of the maximum flow for which the meter is designed. Since the normal meter operates over a range of 1 : 10 this error is restrictive. For a device m = 0·7 an error of 10% would appear at 1/6th of maximum flow.

By contrast normal devices give an error at 1/10th maximum flow of about 2%.

It is now apparent that comparison of primary elements can only usefully be made at values of Reynolds number R_d in the range 800,000 — 1,000,000. Pipe sizes equal to or greater than 8 in. should be used whose friction coefficient data is known to be in the

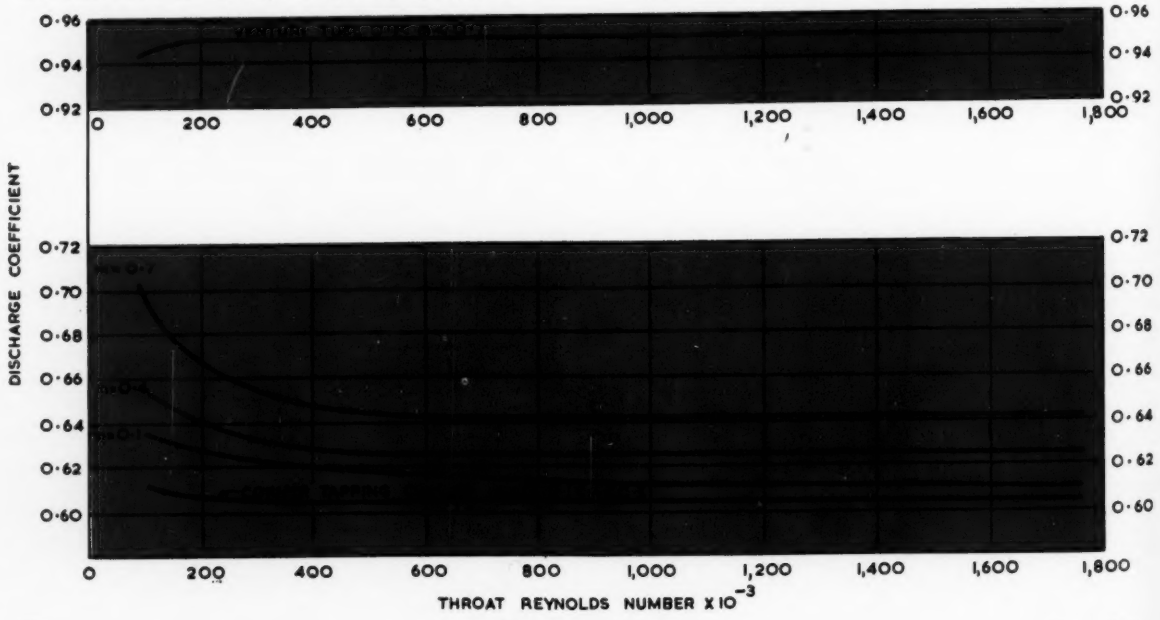
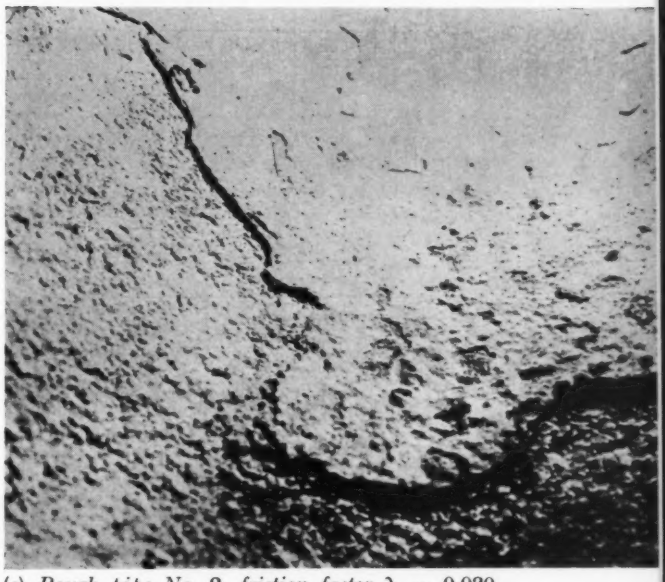


Fig. 4. Significance of constancy limit based on pipe diameter. Coefficient curves of a hypothetical device which has a pipe Reynolds number constancy limit R_D>500,000. The coefficient curves of a standard corner tapping orifice and a nozzle Venturi of representative area ratio are also shown for comparison purposes.

(*a*) *Rough pipe No.* 1, *friction factor* $\lambda = 0{\cdot}032$

(*b*) *General view of rough pipe No.* 2 *looking upstream*



(*c*) *Rough pipe No.* 2, *friction factor* $\lambda = 0.030$

Fig. 5. *Rough pipes used to test existing data*

range $0{\cdot}018 > \lambda > 0{\cdot}01$ and whose length up stream of the test location is at least 60 pipe diameters.

It is, of course, still necessary to test at lower Reynolds numbers in order to establish the extent to which the devices under examination become unstable or too dependent upon viscous effects.

Incidentally, these new devices with high constancy limits raise the practical problem of adequate investigation. There are very limited facilities which will enable these devices, particularly for the larger pipe sizes, to be tested up to the pipe velocities given in Table 3. This is bound to cause some uncertainty as to the true nature of the coefficient curve at these maxima and will restrict the accumulation of data which is so essential for adequate prediction of performance.

This discussion of test arrangement requirements once again underlines the dangers of empiricism in the form which it has taken in the past. None of the points here discussed were taken into account; it is only right to add that some of them—concerned with boundary layer for instance—could not have been appreciated.

Nevertheless, the fault was the attempt to rationalise random data. No amount of juggling with tolerances now can rectify a basic deficiency such as the use of a test pipe 15 pipe diameters in length of unknown characteristics to confirm data obtained in a test pipe 30 diameters in length whose characteristics were also unknown. These are naturally examples imaginary in fact, but quite representative.

Test Arrangements—Rough Pipes

For the tests here reported it was decided to use an 8 in. test pipeline supplied with water under a constant head of 55 ft. The length of straight uninterrupted pipe in front of the test location was 60 pipe diameters.

It was thought likely that the existing data, where available, had been obtained in smooth pipes and it was, therefore, decided to make the first tests of this series using rough pipes. This order would tend to confirm whether or not smooth pipes had in fact been used and, should there be obvious differences in values of coefficients, would indicate the effect of roughness.

As an extension to this intention, it was decided to use two rough test pipes: these were selected primarily on the basis of differing roughness patterns Both pipes have a similar basic roughness, but in the one case the axial spacing between the roughness peaks was greater. This pattern extended over roughly half the internal wall area. The photographs (Fig. 5) attempt to show the nature of the wall roughness in both pipes. The importance of roughness pattern *vis-a-vis* roughness height has already been discussed, and the coefficient data of three primary elements were thought to be an excellent way of checking the effect of roughness pattern as might be indicated in any case by the value of λ obtained for each pipe.

Another aspect which needed careful consideration was the relation of pipe wall roughness to primary element roughness. It has already been suggested

earlier in this article that a primary element and the approach pipe must be, or ought to be, considered as a unit.

Consider the usual state of affairs in this respect whether in laboratory or commercial circumstances.

A brand new Venturi tube is supplied for laboratory test or commercial use; very often the one precedes the other. There is obviously no comparison between the roughness states of pipe and tube. But the clean state of the tube is not necessarily an advantage: firstly, it represents a change of state affecting boundary layer growth; secondly, the clean state soon deteriorates and ages.

It follows that the initial tests will be made under false conditions. Laboratory investigation shows that changes of more than 1% in coefficient value from the clean state can occur after only one or two days' use. The fact that such ageing changes can occur under controlled laboratory conditions where every circumstance is favourable underlines the seriousness of the problem.

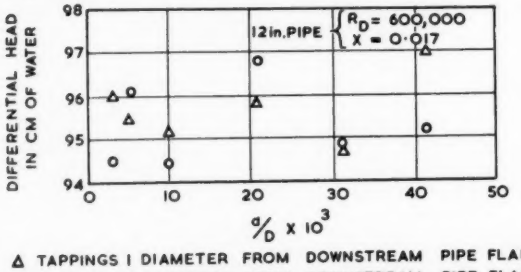
Although there is no reason to suppose that the three devices under consideration would be any different to standard primary elements in this respect, it was decided to make tests in the rough pipes with the internal profile of each device in both a smooth and rough state. In the latter case, an effort was made to reproduce a roughness equal to that of the pipe wall.

Here again the difficulty of assessing past work is obvious from these comments: to ignorance of test pipe roughness and length is now added lack of information about the relative states of the primary devices and the pipes in which they were tested.

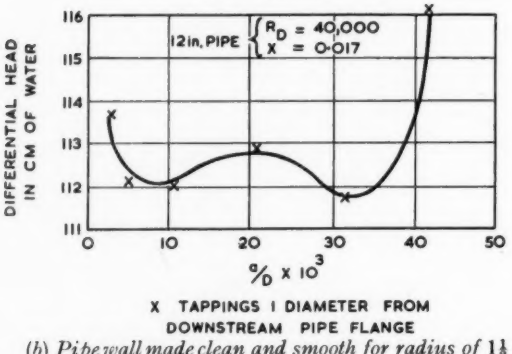
As a general comment, it should be mentioned that the effect of ageing in pipes has been discussed many years ago by Barnes[5] and others, but only recently has the problem, as it affects the performance of measuring devices, been examined by Hutton[6].

In the event that the rough pipe tests gave coefficient

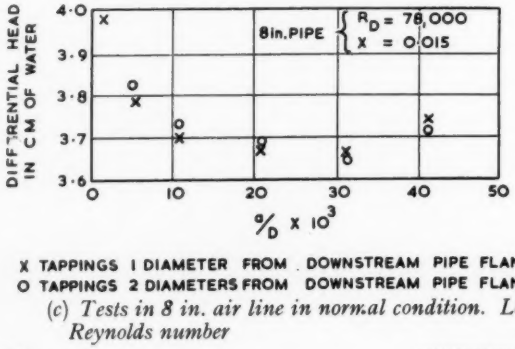
Fig. 6. Influence of pressure hole diameter a = *pressure hole diameter* d = *pipe diameter*


DIFFERENTIAL HEAD IN CM OF WATER
12in. PIPE
R_D = 600,000
X = 0·017
$a/D \times 10^3$
Δ TAPPINGS 1 DIAMETER FROM DOWNSTREAM PIPE FLANGE
O TAPPINGS 2 DIAMETERS FROM DOWNSTREAM PIPE FLANGE

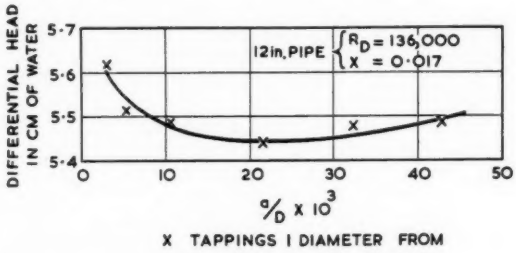
(a) Pipe wall around mouth of hole in normal condition. High Reynolds number



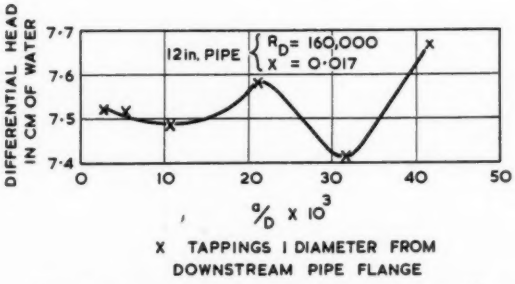
(b) Pipe wall made clean and smooth for radius of 1½ in. around pressure hole mouth. High Reynolds number


DIFFERENTIAL HEAD IN CM OF WATER
8in. PIPE
R_D = 78,000
X = 0·015
$a/D \times 10^3$
X TAPPINGS 1 DIAMETER FROM DOWNSTREAM PIPE FLANGE
O TAPPINGS 2 DIAMETERS FROM DOWNSTREAM PIPE FLANGE

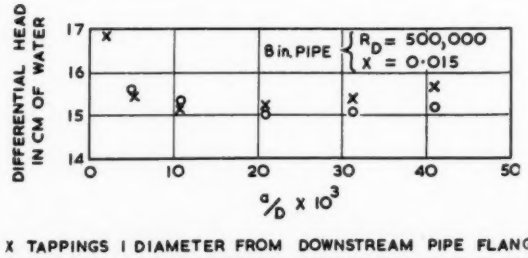
(c) Tests in 8 in. air line in normal condition. Low Reynolds number


DIFFERENTIAL HEAD IN CM OF WATER
12in. PIPE
R_D = 136,000
X = 0·017
$a/D \times 10^3$
X TAPPINGS 1 DIAMETER FROM DOWNSTREAM PIPE FLANGE

(d) Pipe wall around mouth of hole in normal condition. Low Reynolds number


DIFFERENTIAL HEAD IN CM OF WATER
12in. PIPE
R_D = 160,000
X = 0·017
$a/D \times 10^3$
X TAPPINGS 1 DIAMETER FROM DOWNSTREAM PIPE FLANGE

(e) Pipe wall made clean and smooth for radius of 1½ in. around pressure hole mouth. Low Reynolds number


DIFFERENTIAL HEAD IN CM OF WATER
8in. PIPE
R_D = 500,000
X = 0·015
$a/D \times 10^3$
X TAPPINGS 1 DIAMETER FROM DOWNSTREAM PIPE FLANGE
O TAPPINGS 2 DIAMETERS FROM DOWNSTREAM PIPE FLANGE

(f) Tests in 8 in. air line in normal condition. High Reynolds number

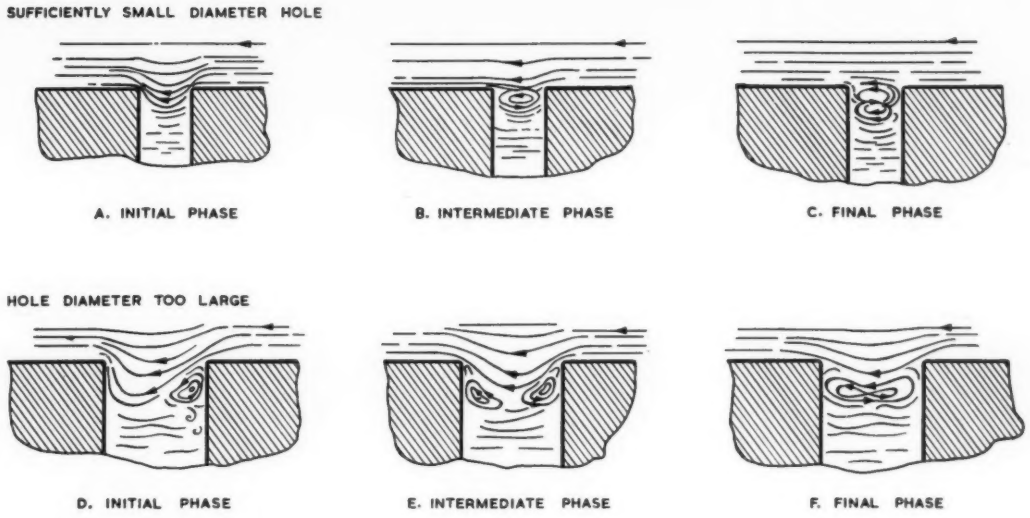


Fig. 7. Flow past a pressure hole

data different from that at present available, it was decided that a repeat series of tests as outlined above would be made using a smooth test pipeline.

Pressure Recovery Tests

The pressure recovery test arrangements also needed consideration. There is no doubt that a lot of the old pressure recovery data for all primary devices are invalid. Earlier in this article some technical reasons were given for this view. There are also some practical difficulties and it is worth reviewing them here in order that some consistency in future experimental work be obtained. A survey of past work in Great Britain, Germany and America shows that the point at which recovery was assumed complete enough for a static pressure measurement to be made was 10 diameters downstream from the orifice plate or throat pressure tapping of the primary element. This distance is quoted here from the throat tapping of a Venturi tube because in some cases it was actually measured from the entry of the device, while in others it was measured from the termination of the diffuser or outlet cone.

There was also a surprising amount of data obtained using a pressure tapping at a distance five diameters downstream! In nearly every case a tapping one diameter in front of the device was used to obtain the initial undisturbed static pressure. The only comment necessary about this latter point is that the position is satisfactory provided that the velocity distribution of the fluid stream at that point is regular and symmetrical.

The same proviso applies or ought to apply to conditions downstream; it follows that a tapping placed five or ten diameters away irrespective of area ratio, of diffuser angle and, most important of all, of the type of device, cannot possibly be in the correct place *vis-à-vis* correct velocity distribution.

There has been much fruitless argument about the need to allow for pipe friction losses which occur in the lengths of pipe between the upstream tapping and the device, and between the end of the device and the downstream tapping five or ten diameters after the device.

If the velocity distribution be accepted as the controlling influence it is clear that no useful allowances for pipe friction effects can be made along a length of pipe in which velocity distribution is imperfectly developed.

The only valid method of assessing the effect, in pressure loss terms, is to choose two points in the pipeline and compare the energy losses between them with and without the primary element in position. It is impossible to apportion losses to this or that effect. To do so involves a process of deception.

There is obviously every reason to choose a downstream tapping position as far away as possible from the primary element to ensure that the velocity distribution is restored to that existing at the upstream tapping.

Therefore, for these tests, a position of the tappings twenty diameters upstream and downstream were chosen. The area ratio of all three devices was $m = 0{\cdot}6$; for smaller area ratios, a considerable increase in these distances, particularly of the downstream position, would have been advisable.

Along with these problems there is the important question of pressure hole size and manufacture. It is, again, common practice to recommend that pressure hole sizes be kept small. To this end the diameters of pressure holes are, in the Standard Flow Codes, related either to pipe or throat size, e.g., 0·1 D or 0·03 d with limits relating to other factors such as area ratio, need to avoid blockage and so on. But there is little fact available to guide the choice of pressure hole size.

Fig. 6 shows the results of some water tests using a 12 in. diameter pipe at a Reynolds number value $R_D > 600{,}000$ in which the static pressure in the pipe was measured differentially by one manometer connected to an independent reference and in turn to six pressure

holes all in the same radial plane, but of different diameters. This sort of experiment is always subject to vagaries in the pipe wall state and, therefore, it was repeated once using another plane displaced axially one pipe diameter upstream of the first set, and for a second time using air in a smooth pipe 8 in. diameter, friction coefficient $\lambda = 0{\cdot}015$, the results of which are also shown in Fig. 6. Furthermore, it seemed advisable to repeat these tests at a lower Reynolds number.

Finally, the tests at both Reynolds numbers were again repeated after the wall of the 12 in. pipe in the vicinity of the pressure holes had been made perfectly smooth in contrast to the initial tests with the pipe wall in its normal condition. It appears that the dish shape of the curves is characteristic and the tests provide some evidence that the hole diameters in the middle of the range are the most satisfactory.

The effect of pressure hole size is related to the extent to which the mouth of the hole will allow the fluid to deviate into it, Fig. 7. When this happens, the downstream edge of the hole becomes a discontinuity which interferes with the natural gradients of flow and pressure. Carried to the extreme, a very large hole could allow flow into it to such an extent as to cause an impact effect, a component of which will be added to the true static pressure.

There has to be a compromise between the theoretical narrow slit or hole and the practical need to avoid blockage; hole diameters of $\frac{1}{8} - \frac{3}{8}$ in. have been much used in the past in a random manner.

In the light of the paper by Morris[4], it may be that future recommendations must be related, in particular, to both roughness height and spacing. In other words, the sizes must be related, in effect, to the friction factor λ in addition to the usual parameters.

Finally, in this discussion of test installation requirements, it is sufficient to remind the reader that careful measurement of pipe diameter, roughness and of the geometry of the primary element must be made. This is essential along with the checking of basic information such as density, viscosity, gravity acceleration values at the test location and the need to ensure that manometers are set correctly and that temperature measurements are reliable. If air is used (with reluctance!) for basic tests, then the importance of compressibility and humidity must not be forgotten.

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Note.—The following reference applies to Fig. 6:—
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Symposium on Electronic Instrumentation for Nuclear Power Stations

A SYMPOSIUM on Electronic Instrumentation for Nuclear Power Stations was held by the British Institution of Radio Engineers on 29th March. It was divided into two sessions. At the first session papers were presented on Systems and Stations and at the second session papers on Circuit Techniques were presented.

1st Session: Papers on Systems and Stations

Background Factors to the Design of Control Equipment for the Civil Nuclear Power Stations

R. D. TROTTER (Central Electricity Generating Board)

The design of the control and indication facilities required to supervise the equipment of a nuclear power station must be based on an appreciation of the methods of operation of the plant, and the staffing of the station.

The first nuclear stations are expected to operate at very high load factors as base load stations for the transmission system. This criterion leads to station layouts designed to use the minimum of staff on day-to-day operation and to the use for each station of a central control room. This paper attempts to outline the layouts of equipment which have been adopted for the first six C.E.G.B. stations and to serve as an introduction to other papers of this symposium which describe the instrumentation of two stations in detail.

Instrumentation at Berkeley Nuclear Power Station

R. E. B. DAWSON and M.W. JERVIS (The Nuclear Power Group)

From the shutdown power of about 10 watts upwards, nuclear (neutron flux) instrumentation is used for reactor power measurement and to operate safety trips if the power is raised too quickly or beyond a pre-set value. This nuclear instrumentation comprises a total of 11 linear and logarithmic channels.

At higher powers, control and protection is based on

temperature measurements, about a thousand thermocouples in each reactor being installed to measure fuel element, channel gas, graphite and other temperatures. Selected fuel element temperatures can shut down the reactor, others being recorded by an extensive system of multi-point 10 inch recorders and automatic loggers.

The shutdown initiating devices are triplicated and fed into a safety system which shuts down the reactor only if at least two out of the three give a trip signal. This reduces the possibility of spurious reactor trips caused by failure of the trip devices, which are of the " fail safe " type.

The system of faulty fuel element detection employs an automatic logger which computes averages, so giving discrimination between random and significant rises in CO_2 gas activity, indicative of defective fuel elements. The automatic logging also relieves the operator to a large extent of the burden of examining the large number of graphical records and gives a degree of data reduction.

Equipment is also provided for the detection of leaks between steam and CO_2 circuits; in addition radiation and activity in and around the station is monitored. Gas and steam flows are measured and the data transmitted by a pneumatic system.

The display equipment for the major instrumentation is centralised in or near the station control room. Instrumentation on vertical panels is provided for long term recording and control whilst the minute-to-minute operation is effected from the control desk.

Reactor Instrumentation at Bradwell and Latina Nuclear Power Stations

R. V. INGHAM (The Nuclear Power Group)

The paper covers the reactor instrumentation at Bradwell Nuclear Power Station as designed and supplied by the Nuclear Power Group to meet the requirements of the Central Electricity Generating Board tender specification and approval of the United Kingdom Atomic Energy Authority.

The instrumentation of the Latina station as described follows current British practice with the addition of certain contemporary Italian ideas to the approval of the United Kingdom Atomic Energy Authority.

Neutron flux measurements designed to cover the full range of reactor power are described, together with neutron flux plotting techniques.

At full power temperature measurements become all important due to the limitation of the magnox fuel element can. Temperature measurements necessary for reactor control and safety are described with reference to technique and application.

In order to detect failure of the fuel element sheath a detection system based on the electrostatic collection of solid fission products is installed. The Bradwell system described differs somewhat in mechanical detail from Calder Hall.

Measurements in the coolant gas circuit primarily concerned with the maintenance of adequate coolant flow and the integrity of the pressure circuit are described.

Reference is made to the overall station automatic control and the special regulating rods installed to meet the predicted performance of the reactor.

Points of interest in the main control room concerning layout and operation are described.

Overall Latina instrumentation, being essentially similar to Bradwell, is not discussed, but reference is made to the degree of centralised control at Latina and special features arising from Italian influence on instrumentation philosophy.

Hinkley Point Temperature Scanning Equipment

R. I. OSTLER and J. M. TYRRILL (Marconi Instruments)

The equipment described is a data handling system with magnetic drum storage. Graphite, fuel element and gas exit thermocouples are scanned and the remainder of the 720 input positions are used for self-checking purposes. It is a high speed system, taking 144 seconds for a complete scan. There is a memory of 20 scans, representing 48 minutes. The long life and extreme reliability of input switching required is achieved by using reed relays driven by transistors in a matrix arrangement. The equipment is unusual in that analogue to digital conversion is performed directly on the outputs of the thermocouples. Since the converter has a high input impedance it does not affect other equipment, e.g., pen recorder, in parallel with it. A circuit has been developed to linearise thermocouple signals so that the output is in degrees centrigrade rather than thermocouple e.m.f. The magnetic drum storage and arithmetic circuits employ conventional medium speed computing techniques. Read-out is on strip printers, a typewriter and a tape punch. The latter is used when a reactor trip occurs, to record a complete back log. The operating range of the equipment is from 0 to 700°C, the long term overall accuracy (excluding thermocouple variations) being ±30°C.

Hinkley Point Neutron Flux Measurement System

P. J. KEELEY (Marconi Instruments)

The paper describes the instrumentation used for the measurement of neutron flux with particular emphasis given to the method of operational testing of the various measurement channels.

A d.c. system of measurement is used throughout the entire range from start-up to full power. The use of a large installed neutron source together with gamma compensated ion chambers obviate the need for pulse counters at very low power levels. The completely d.c. system results in (a) simplified instrumentation, (b) simplified operational testing and (c) reduction in types of instruments held as spares.

Instrument cubicles contain built-in test facilities such that operational or day-to-day testing can be carried out by one person without the use of portable test gear. Remotely situated head amplifiers are included in this test, necessitating the use of high insulation relays for switching input currents as low as 5×10^{-12} amperes.

2nd Session: Papers on Circuit Techniques

The Shutdown Amplifier

J. HAZELL (General Radiological)

The shutdown amplifier supplies information to the

safety circuit, so as to cause a reactor to shut down as the power rises above a predetermined level.

The current from a neutron-sensitive ion chamber produces a signal, proportional to reactor power. A second, reference, signal is calibrated in terms of power level. The amplifier gives a " safe " output only when the power signal is less than the reference setting. All other conditions, including failure of the amplifier, give a " trip " output.

It is vital that a " trip " output is obtained when a genuine trip condition exists and that the amplifier is as reliable as possible to avoid a high spurious " trip rate ". The amplifier is arranged to produce an output in the " safe " condition and no output in the " trip " or failed conditions. In addition, the amplifier is normally overloaded so that a rapid changeover from " safe " to " trip " is obtained as the power level approaches the trip setting.

The Use of Transistors for Reactor Instrumentation

E. P. FOWLER (Atomic Energy Establishment)

The requirements of reactor instruments are a combination of the philosophy of fail-to-safety, assumed supplies in all circumstances and reliability over a long time of operation. The special advantages of transistors in the development of these instruments are simplicity of circuit and economy of power required. As a result, a greater emphasis can be placed on a.c. or pulse operation of circuits which, although inherently more complex, can be made much safer than d.c. operation.

A description of the salient features of some early instruments, on which we now have some maintenance data, shows that it is very easy to get a poor maintenance record with personnel initially unskilled in the testing of transistor circuits. Although these older instruments are possibly no improvement over existing valve equipments, except in their smaller size and panel requirements, those now being produced have much better performance.

New instruments designed for the U.K.A.E.A. take their power from a d.c. supply of 50 volts centre-tapped or from the a.c. mains which considerably eases the provision of stand-by facilities. Notable among these are:

1. A logarithmic amplifier and periodmeter with a wide range, fast response and no period overshoot.
2. A potentiometric recorder with a 4 in. chart, 1 second response and 0·2% sensitivity available in a single point and six point version.
3. The pulse counting channel described in another paper.

The trend in the future would appear to be toward wider range instruments, greater inherent safety by the use of more a.c. techniques and the provision of more continuous self-checking facilities. Already a low power reactor is to have solid state safety circuits by the end of this year together with all-transistor instruments which it is hoped will show a very high order of reliability and safety.

The Design of a Pulse Counting Instrument for the Measurement of Neutron Flux

R. B. STEPHENS, J. N. EVISON (Mullard) and E. P. FOWLER (Atomic Energy Establishment)

The start-up of a nuclear reactor, especially after loading with new fuel, is one phase of operation requiring the utmost care. In this region, many decades of power below the normal operating level, the best possible method of reactor control is by the use of pulse counting channels for the measurement of neutron flux. These channels can have operational checks made during normal use by the use of marginal test facilities which make them inherently safer than equivalent d.c. channels.

By using transistors a complete pulse counting channel can be housed in one box. This is probably the most spectacular improvement obtainable by going over to transistor instruments. The design of such an instrument must take into account the nature of the pulses received from the neutron detector and the operational requirements of the system. Consideration must be given to the random time distribution of the detected pulses and the consequent effect of both the speed of operation required of the electronic circuits and on the accuracy at low counting rates.

The use of a low level discriminator simplifies the pulse amplifier design. The amplifier/discriminator combination then exhibits the necessary sensitivity and time resolution with a reliability which is enhanced by the simplicity of the circuits. The logarithmic ratemeter uses the well-tried multiple diode pump circuit, but the drive circuits are of interest in view of the short time resolution required at high count rate. The stable high voltage supply (2·5 kV) to the neutron detector is generated in the instrument and has a stability of better than $\pm 0{\cdot}5\%$. Three alarm or " trip " circuits are provided for indication of abnormal conditions.

Details are given of the mechanical construction of the instrument and the considerable reduction in size over the comparable valve equipment illustrated.

Application of Transistor Techiques to a Thermocouple Trip Amplifier

G. G. BALLARD (Elliott Nucleonics)

The general requirement of reactor protection against excess temperature operation is becoming increasingly critical due to the higher power demands imposed on nuclear stations and the consequent fine limits set between the working temperature and the corrosion temperature of the fuel cladding. To combat this problem reliable thermocouple trip amplifiers have recently been developed.

Design requirements applicable to these units are discussed together with fail-to-safety features including some mention of two out of three systems.

The basic concept of a fail-safe equipment is an ability to provide a trip indication should the input temperature exceed a predetermined level or any component or combination of components fail to a short or open circuit. This result may only positively be achieved by use of an a.c. carrier technique employing some form of modulator.

Protection against external failures, for example, thermocouple open and short circuits, are discussed and the method of surveyance is detailed.

The problems of producing a suitable modulator which will function in a fail-safe manner and produce the low drift voltage required for use with thermocouples are discussed with particular emphasis on the transistor chopper.

The latter part of the paper is devoted to a particular design of trip amplifier, and details of the circuits employed to produce a reliable, fail-safe unit are given with specific reference being made to features which render the unit safe.

A Gamma Radiation Monitor

A. A. LUSKOW (Marconi Instruments)

The instrument described is used to monitor the gamma radiation in the vicinity of a nuclear reactor. The combination of ionisation chamber and d.c. chopper amplifier produces a monitor which measures radiation dose rates in the range 0·1 to 100 mR/hr. The log-log response allows the full range to be displayed without range switching and provides an expanded lower decade, so that radiation levels around the tolerance can be measured reasonably accurately and yet the instrument remains on scale should a high level of radiation occur. A high dose rate alarm is provided and its trip level can be set at any point in the range. Provision is made for operating an external recorder and alarm. The circuit is fully transistorised except for an electrometer triode.

BOOK REVIEWS

Dictionary of Automation, Computers, Control and Measuring. *By W. E. Clason. Elsevier Publishing Co.* 1961. £7.

This multi-lingual dictionary in six languages, English/American, French, Spanish, Italian, Dutch and German, has been compiled and arranged on an English base. Corresponding words in each language are arranged horizontally.

The range of terms covered by the dictionary is indicated by the title. In addition, the author has included a comprehensive list of measuring instruments, and terms from such neighbouring fields as machine translation, information theory and automation. The vocabulary of control techniques has been kept to the minimum owing to the present lack of internationally accepted definitions.

There are 3,390 terms listed in the basic table, each term being numbered. The English/American terms are defined, and an indication is given of which subject each term applies to, e.g., electronic computers, control, circuitry, information theory, etc., and whether the term is obsolete or slang. (Though here the British view of what is slang differs somewhat from the American.) The corresponding terms in French, Spanish, Italian, Dutch and German are then listed together with their genders.

For each language there is an alphabetical list of words referring to the corresponding numbers in the basic table. A system of thumb indexing has been adopted to enable these lists to be located easily.

The pages are unnumbered throughout the dictionary, an attached ribbon being available for retaining one's place.

It is a pity that in view of the considerable amount of work that is being done in the U.S.S.R. in the field covered by this dictionary, and the number of research papers that come from the U.S.S.R. on this subject, that the equivalent Russian terms could not also have been included. Although some terms which are current in British work in this field will not be found in this dictionary, one may say that the coverage as a whole is good, and the production of the book excellent.

Precision Measurement and Calibration, *National Bureau of Standards Handbook* 77, *issued February* 1, 1961, *three volumes: Vol.* I, Electricity and Electronics, 845 *pages*, $6.00; *Vol.* II, Heat and Mechanics, 965 *pages*, $6.75; *Vol.* III, Optics, Metrology, and Radiation, 1,025 *pages*, $7.00. (*Order from Superintendent of Documents, U.S. Government Printing Office, Washington,* 25, *D.C.*).*

This handbook is a compilation of the more important National Bureau of Standards publications over a period of years, dealing with precision measurement and the calibration of standards. The handbook divides the subjects in the fields of precision measurement and calibration into three separate volumes: I, Electricity and Electronics; II, Heat and Mechanics; and III, Optics, Metrology, and Radiation. This new compilation is intended to serve as a quick reference source for workers in the field of standards, and also as a textbook and aid to scientists and engineers in standards laboratories.

The tremendous increase in industrial activity, particularly in the missile, rocket, and satellite fields, has created an unprecedented demand for precision measurement. This, in turn, is bringing about the creation of hundreds of new and highly specialised laboratories. Among the thousands of scientists, engineers and other workers connected with these laboratories are many not previously trained in work on standards. For all these persons, trained in the field or not, the Precision Measurement and Calibration Handbook will constitute an authority comparable to the familiar handbooks of chemistry, physics, and engineering.

The publications, originally issued as circulars, research papers, chapters of books, and articles in scientific periodicals, were selected for inclusion in the handbook on the basis of their having, in the past, best served the needs of scientists in specialised fields of measurement. The list of specific titles included in each volume is given in the table of contents of that volume. Because the three volumes are being sold separately, the subject index and authors' index are complete and identical in each volume.

*Remittances must be in U.S. exchange and should include an additional one-fourth of the publication price to cover mailing cost.

(*Continued on page* 576)

SIMA Notes

10th Electrical Engineers' Exhibition

Thirteen members and five associate members exhibited at Earl's Court and, in general, members considered this to have been most successful. Possibly the most prominent exhibit was the 17 foot square dial installed on the Warwick Road balcony by Nalder Bros. & Thompson Ltd. which showed the exhibition load in megawatts. It is noteworthy that in addition to this monster instrument, its identical "baby brother" of 1¼ in. diameter, was on display on the Nalder Bros. & Thompson stand.

Japanese Import

A delegation of representatives of the Scientific Instrument Manufacturers' Association, British Industrial Measuring & Control Apparatus Manufacturers' Association, the British Photographic Manufacturers' Association and the Drawing Office Material Manufacturers & Dealers' Association, led by Mr. G. C. Ottway, President of SIMA, was received by Sir Richard Powell, Permanent Secretary of the Board of Trade, to hear the views of these associations on the future impact of Japanese imports of instruments on the home market.

British Instruments Directory, 1962

The preparation of the 1962 edition of the British Instruments Directory & Buyers' Guide is now in hand; this edition will be larger than before and will include an additional glossary of technical terms in Russian. The Directory will be published by United Science Press in conjunction with the Scientific Instrument Manufacturers' Association. SIMA members will receive special rates for advertising and will be entitled to a free copy. Some 9,000 copies will be produced and distributed world wide.

Standardisation in the Field of Ultrasonics

An organisation has been set up under the chairmanship of Mr. W. Owen Roberts, of Mullard Equipment Ltd., to consider the problems of standardisation in measurement and terminology in the field of ultrasonics. An executive committee of member companies consisting of Mullard Equipment Ltd., W. Bryan Savage Ltd., Dawe Instruments Ltd., Kelvin & Hughes Ltd., and Standard Telephones & Cables Ltd., will co-ordinate the work, and appoint working parties to consider the various problems arising. Any United Kingdom companies working in the field will be invited to assist in these working parties, whether members of the association or not, and consultation will take place at the appropriate times with other national bodies such as the Medical Research Council, the British Standards Institution, etc.

Meeting of the Nucleonics Group and Section 6

A meeting was held at the Connaught Rooms on Thursday, 16th March, under the chairmanship of Mr. E. B. Thompson, Ekco Electronics Ltd. The meeting heard a most interesting talk by Mr. H. D. Binyon, of The Solartron Electronic Group Ltd., on his experience during a recent visit to China which included many points of great practical value for those members considering export activities in this market. Some 67 representatives from 29 member companies attended, and amongst matters discussed were the level of safety requirements for electronic capital equipment, the requirement for national standards for electrical measurement in the high frequency field, the future work in the field of ultrasonics, referred to above, collaboration with the Radio and Electronics Measurements Committee of the Ministry of Aviation, use of isotopes in the textile industry, and various matters in connection with exports and exhibitions. This latter included an invitation to organise an exhibition at Imperial College in connection with their Summer School on Health Physics, and Mr. R. H. Cooke, of Research and Control Instruments Ltd., and Mr. F. M. Peters, of Baldwin Industrial Controls, have agreed to act as co-ordinators, and are in consultation with the College authorities.

Sima Export Forum

A new activity in the field of exports is being initiated.

A SIMA Export Forum, under the chairmanship of Mr. P. Schilling, of Stanton Instruments, was held on the 2nd May and from indications received from members it appears that some 150 will be attending. The first forum will take the form of a Brains Trust and will deal with the general field of export problems. The aim will be to assist members, in particular the smaller firms, to deal with the problems of expanding their export business in new markets. Later forums may deal with limited or specialised fields, possibly on a territorial basis.

I.E.A. Exhibition

Mr. L. A. Woodhead, of Cossor Instruments Ltd., has been appointed chairman of the I.E.A. Exhibition Committee for 1964.

Annual Luncheon

The Annual Luncheon of the Association is being held at the Savoy on Thursday, 11th May, 1961. Sir Howard Florey, President, Royal Society, has accepted an invitation to be the principal guest.

New Members

The following new members have recently been elected:

P.S.B. Instruments Ltd.,
Elga Products Ltd.,
Newmark Instrument Ltd.

and as an associate member:

Scientific Lens Co. Ltd.

Apprenticeship Certificate

The Apprenticeship Certificates of the following member firms were endorsed by the official seal of the Association indicating that a course of instruction, approved by the Association, had been carried out:

R. & J. Beck Ltd.	1
C. Baker Instruments Ltd. ...	2
Taylor, Taylor & Hobson Ltd.	3
Hilger & Watts Ltd.	12

The basic workshop facilities required for the maintenance and minor development of a medium size instrument installation are considered. The lay-out, services, equipment, costs and organisation of an actual workshop are described in detail and some of the more general and, perhaps less tangible, aspects of instrument maintenance are discussed.

Design and Organisation of an Instrument Workshop

A. H. HOSKINS*

Introduction

IT has, for many years, been common industrial practice to regard instrument facilities as an irritating, if necessary, adjunct to the main business of providing premises for the mechanical and other major engineering sciences. Evidence of this attitude is still to be found in the cramped and ill-equipped accommodation so often labelled " instrument workshops " in present-day factories.

Where the volume of instrumentation is small, the original suppliers of the equipment can be used to carry out all but the simplest maintenance work, and comprehensive facilities are not then required. The problem is to determine at what stage in the development of factory instrumentation such facilities are economic and worthwhile. Policy must necessarily depend upon considerations of production and amenities peculiar to each organisation, but it is suggested, generally, that a fully staffed and equipped workshop becomes profitable when more than 200 recording/controlling applications are employed.

The most important reason for user-maintenance is the need for speed in restoring an application to normal following breakdown. An important measurement may be interrupted due to something as trivial as a defective pen on the one hand to a seriously damaged measuring element on the other, and the true criterion of workshop requirements is the effect of such failure on production. Obviously the dependence on individual items can be minimised by as great a degree of standardisation as possible, but complete success in this field is unattainable, and the question of delay must ultimately be faced. In a well-appointed factory workshop it will be possible to carry out any type of repair at short notice and, providing adequate stocks of spares are maintained, reduce instrument " down-time " to an absolute minimum.

Part I
Location and Lay-Out of Workshop

Although in the established works location will necessarily be limited by other considerations, it is emphasised that the nature of instrument work, if only in a numerical sense, entails heavy traffic between workshop and plant. For this reason, the workshops should be sited near to the heaviest concentration of plant applications. In the larger factory small sub-workshops are often justified but these can only be used for fitting and minor repair work and present no solution to the transportation problem. Proximity to other maintenance facilities such as the mechanical and electrical workshops is also obviously desirable and in many concerns the various departments are often housed in one building.

Size will, of course, be the first consideration in the design of a new workshop. In the author's experience instrument workshops are invariably inadequate for the work-load experienced and this is believed attributable, amongst other things, to a false concept of the class of work in question. It is suggested that industrial instrumentation, in the prodigious variation of its present-day form, is still sometimes confused with its " watchmaking " connotations of the past.

Before deciding upon even approximate requirements, therefore, a complete inventory of instrumentation in

*Works Instrument Engineer, The Associated Ethyl Co. Ltd.

the factory should be compiled. From this, rough estimates of the basic work-load can be prepared by:

(a) estimating how often each separate instrument item will be overhauled, say, once a year
(b) allowing it the appropriate number of man-hours in the workshop.

As a guide, twelve man-hours has been found to be a satisfactory datum for annual overhaul of pneumatic transmitters, controllers, control valves, etc., by a reasonably experienced mechanic. A factor of not less than 50% should be added to this basic load to allow for unavoidable variations in the weekly work increment, for non-scheduled (breakdown) work, and for the ancillary work such as storekeeping, cleaning and machining that is anticipated.

The amended work-load estimate gives an immediate indication of both personnel requirements and daily work distribution. From these two parameters the detailed design of workshop size and lay-out can be determined.

Part 2
Description of a Typical Workshop

Lay-out

The plan of a moderately successful workshop is shown in Fig.1. The weekly loading on this shop, approximately one fiftieth of the total factory instrumentation, is shown in Table 1, and is carried out by a staff of 12 instrument mechanics under the supervision of one chargehand and one foreman. Two or three apprentices, two tradesmen's assistants, and an engraver, are also employed but are mainly engaged on ancillary work.

The workshop is located on the first floor of a larger building, and has the disadvantages of poor natural lighting and difficult access. Access has been greatly improved by the installation of a fast passenger/goods lift and adequate artificial lighting has been provided as described later.

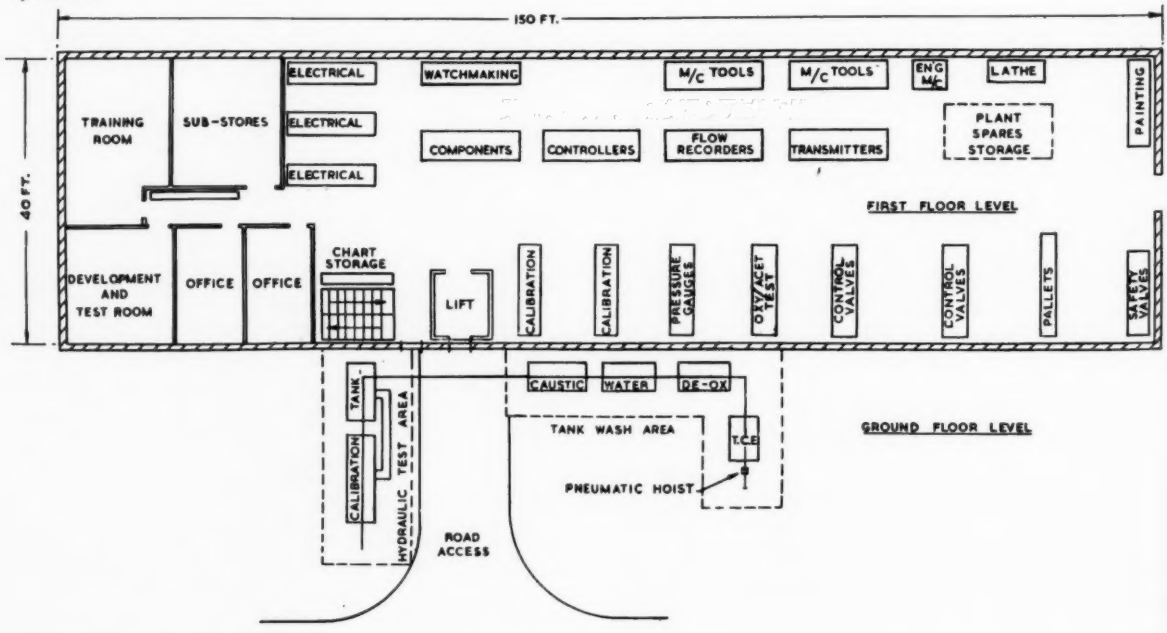
Besides the normal maintenance facilities, provision

Table I.

Workshop nominal weekly load

Instrument Type	Number Received in Workshop per Week.
Recorders—standard pneumatic receivers	2
Recorders—standard pneumatic controllers	3
Recorders—mercury manometers	1
Recorders—standard filled temperature systems	1
Indicator/Controllers — standard filled temperature systems	3
Controllers—" blind " pneumatic systems	3
Controllers—mechanical pneumatic controllers	1
Recorders—electronic potentiometers	2
Indicators—electronic potentiometers	1
Controllers—potentiometer pneumatic/electrical	1
Transmitters—mechanical pneumatic	5
Transmitters—mechanical electrical	2
Control valves	10
Safety valves	10
Pressure gauges, temperature indicators, level indicators, etc.	50

Fig. 1. Diagrammatic plan of workshop and external facilities



has been made in this workshop for a training room. This is to be fully equipped with demonstration rigs and facilities for carrying out work under close supervision and will be used for the teaching of instrument theory and practice on existing and new types of equipment. Also included is a small instrument development room which is to be used for instrument evaluation and other investigational work.

A small sub-store is maintained to avoid delays that would be incurred in the procurement of innumerable small items of common usage and also to house the special hand-tools and test equipment that are in intermittent use.

Immediately outside the workshop, on the ground floor, a hydraulic testing station and a cleaning and degreasing plant is housed.

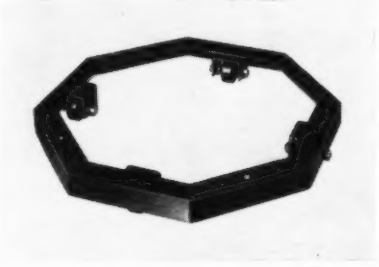
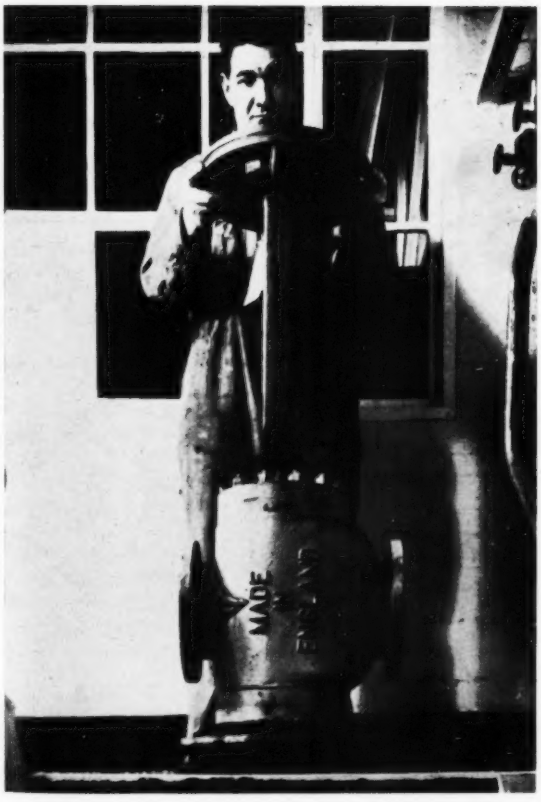


Fig. 2. Low loading bogie (*By courtesy of Messrs. Powell & Co. Ltd.*)



Services

Air

To minimise pressure drop and to provide maximum flexibility, dual 1 in. ring mains are installed. These run below the floor with risers at each bench unit and carry 100 p.s.i. and 40 p.s.i. compressed air respectively. The 40 p.s.i. supply consists of dried, oil-free air, and is used for all instrument supplies. The normal 100 p.s.i. factory air is used for pressure gauge calibration and general work, but it is intended to boost this pressure to 400 p.s.i. in the near future to extend its use. In the interests of safety, all high-pressure testing is at present carried out hydraulically using an air-to-water reciprocating pump developing 1,800 p.s.i. Oxygen/acetylene and other high-pressure equipment is maintained in the workshop, however, and these are finally set on a special bench fitted with a 2,000 p.s.i. nitrogen supply obtained from cylinders.

Electricity

Company standards ensure that all instrument power requirements are limited to 110 volts, 50 cycles, alternating current. Two ring mains of suitable rating are therefore installed at ceiling height with two or more fused outlets at each bench unit. Supplies for machine tools and other permanent fixtures are also distributed in this trunking with outlets and isolators at the appropriate positions. Portable transformers and rectifiers are used for the local generation of special d.c. requirements when required, i.e., for bridges, desyns, etc.

As previously mentioned, natural lighting in the workshops is poor and artificial lighting has been designed to provide a minimum of 50 foot-candles at all working surfaces. Such illumination is considered essential for the efficient utilisation of test equipment with finely divided scales and for the other precision work commonly encountered.

Handling Equipment

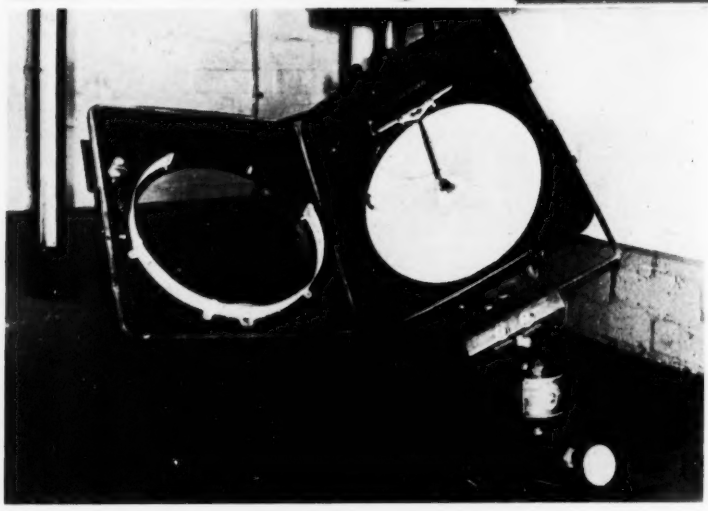
Heavy items are off-loaded from plant transport with a pneumatic hoist passing across the main workshop entrance. They are transferred from this hoist to either specially adapted bogies or a mobile floor crane and wheeled into the workshop lift. From here they are passed direct to the appropriate area of the workshop and transferred to timber pallets.

The bogies used have been found to be particularly useful. They are of the form shown in Fig. 2—the use of "rocking" castors in two planes rendering them extremely manœuvrable. Such units are inexpensive and it is economic to employ a number, each fitted with tailor-made cradles for specific lifts.

During overhaul it is desirable that work-pieces be held safely and conveniently, and it is considered that time spent on the fabrication of suitable fixtures is amply repaid. For control valves and similar weighty items a low timber or steel plinth fitted with a slotted-flange yoke will be found invaluable and avoids unnecessary handling. In use, one flange of the item undergoing overhaul is bolted to the fixed flange and held in the required position. For bench work, simple

Fig. 3. "Hydraclamp" work positioner

(By courtesy of Messrs. Spencer, Franklin Ltd.)



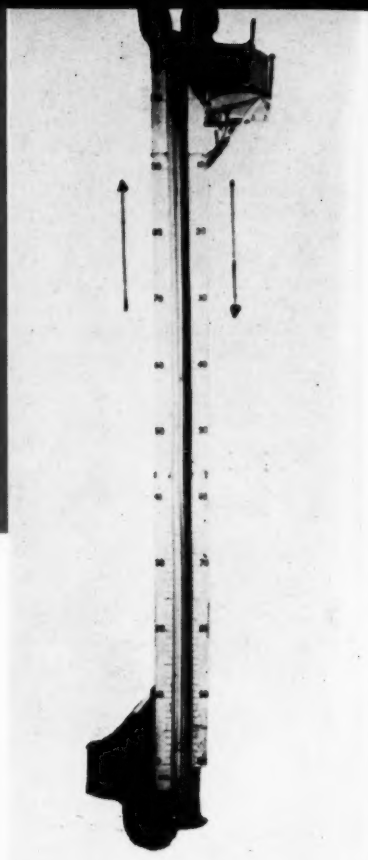


Fig. 4. 100 *lb double-link workshop manometer*

(By courtesy of Messrs. Foxboro-Yoxall Ltd.)

revolving frames can easily be designed to accommodate the most irregularly shaped instrument. A standard fixture known as the "Hydraclamp" is shown in Fig. 3. This also can be fitted with special purpose holders and allows finger-tip control of the heaviest loads.

Chemical Treatment

To reduce the proportion of non-productive time spent on pre-overhaul cleaning, a simple wash plant is installed outside the workshops. This plant consists of steam-heated caustic, phosphating and trichloroethylene tanks served by an overhead pneumatic hoist.

Incoming instrument items, such as regulating units, are passed through tanks appropriate to their condition before receipt in the shop. The removal of paint, rust and other deleterious materials greatly assists the preliminary workshop inspection and subsequent dismantling, and ensures that the minimum of dirt is carried into the shop.

Board-mounted recorders and similar items are not, of course, treated in this summary fashion. A small bench-mounted rotary degreaser is used for the cleaning of the internal parts of such instruments during overhaul. All items that require re-painting, however, are passed through the outside T.C.E. degreaser immediately prior to priming to remove any oil and grease present.

A small painting section is maintained in the workshop to avoid the delays that would inevitably occur if external co-ordination of such services were required. Even so, it is often difficult to reconcile painting time with other requirements and alternative finishes and techniques are constantly being considered.

Equipment

The scope of this paper does not allow a detailed description of the equipment employed in the workshop, but some of the more important items are enumerated to indicate what experience has proved to be justified for the volume of work undertaken.

Machine Tools

One 4 in. Smart & Brown S.C. precision lathe
One Pultra micro-precision " watchmaker's " lathe
One Sigma universal milling machine

One " Centec " bench-mounted horizontal milling machine

One " Pacera " $\frac{3}{4}$ in. drilling and tapping machine

One " Corona " $\frac{1}{4}$ in. precision high-speed drilling machine

One Taylor, Taylor & Hobson engraving machine.

Besides the usual tradesmen's tools, a comprehensive stock of micrometers, height gauges and other vernier measuring tools are essential to cover needs. These are housed in the workshop sub-stores and issued on short term loan as required.

Test Equipment

One bench-mounted precision potentiometer
One bench-mounted precision Wheatstone bridge
One bench valve characteristic meter
One Cossor double-beam oscilloscope and camera
Various portable potentiometers, bridges, multimeters, valve voltmeters, decade boxes, etc.
Two dead-weight testers, 2,000 p.s.i. capacity
Various volumetric gas test meters up to 5 ft³/min n.t.p. capacity
Various precision micro-manometers
Three constant temperature baths. Range 0–300°C.
Multi-point precision temperature indicator
Two rotary vacuum pumps
Portable universal pitometer test equipment
Anemometers, tachometers, planimeters, etc.

Fabricated Equipment

A great deal of built-in testing equipment has been provided where this is necessary to speed maintenance work. All of the bench units, for instance, which are standard 12 × 3 × 3 ft timber or steel items, are piped on the underside with compressed air and electricity. The compressed air arrangement includes snap couplings, built-in reducing valves and pressure gauges to facilitate rapid connection and alignment checks.

Pneumatic calibration equipment is so arranged that any test pressure between 30 in. vacuum and several hundreds of pounds per square inch is immediately obtainable, and is orientated so that this is applied to the correct reference instrument.

The most commonly used standards for routine pressure work are mercury and water manometers and various ideas have been developed to render these fool-proof and non-fatiguing in use. A most useful form has been found to be of the type shown in Fig. 4. It consists essentially of two single-limb manometers linked to give reverse movement of level so that full pressure readings are obtained over half the normal scale length. Zero errors are immediately apparent at the 50% graduation during normal operation, thus minimising faulty calibration.

It has been found that pressure gauge calibration is most expeditiously carried out using air as the checking medium. A twelve foot bench has been fitted with a manifold enabling several gauges to be tested simultaneously and has built-in reducing valves and high accuracy test gauges. The test gauges are themselves calibrated at regular intervals on the dead-weight tester.

Part 3

Workshop Maintenance, Programming and Control

Maintenance

Generally it is convenient to classify all instrument work in three grades as follows:

" Heavy "—Control valves, reducing valves, safety valves and similar mechanical items.

" Standard "—Recorders and indicators of a general mechanical-pneumatic nature. Component overhaul and machine work.

"Electrical"—Potentiometers, analysers, voltmeters, ammeters, etc. Fabrication of electrical components and sub-assemblies.

It has been found, despite comprehensive training, that definite aptitudes for one or other of the above grades of work exist in the workshop staff, and that best results are obtained if this is recognised in the allocation of work and the arrangement of the workshop.

All routine " thorough " overhauls fall naturally into five separate operations, viz: cleaning, inspection, dismantling, assembly (including parts replacement and alignment) and calibration. Operation 1 would normally be carried out by an unskilled person, 2, 3, and 4 by the instrument mechanic, and item 5 by a separate calibration mechanic. Using a specialist calibrator has advantages in that defects are less readily accepted from the previous stage of work, and that calibration techniques are easier to implement and control if the minimum of people are involved.

Emergency breakdown maintenance will vary from the above procedure according to the nature of the defect and the time available. In all cases, however, the problem resolves mainly into a matter of spare part availability and close technical supervision, and no amount of expensive equipment or spacious accommodation will remedy delays and eventual plant failures due to neglect of these two factors.

Programming and Control

The basic workshop load is derived from the long-term routine maintenance programme and is of the order shown in Table 1. All instrument equipment is referred to by an identifying " tag number " and routine work lists are issued by a central records section one week in advance.

A short daily meeting between engineer and supervisors is held to review the current day's work and to plan for unscheduled work such as breakdown, fabrication of components, maintenance of minor items such as pressure gauges, thermometers, etc. A simple form of the type shown in Table 2 is found invaluable for quick co-ordination of this type of work. The basic day's work for three or four plants and the workshop is integrated in minutes while retention of the summary by the engineer engenders sufficient measure of formality to ensure execution of the work. A more detailed programme is, of course, required by the supervisor for workshop use.

A standard arrangement with process managements calls for the removal and reinstallation of all "routines" within a 48-hour period. Non-routine work is carried out in the shortest possible time, of course,

Table 2

Instrument Department—Daily Work Programme

	Routines			Hours		Planned			Hours	
	Tag No.	Item	Action	Est	Act	Tag No.	Item	Action	Est	Act
CHLORINATION	(1) *FRC 110*	*Tx*	*Remove*			(1)				
	(2) *PRC 108/2*	*Rx*	*Remove*	¼		(2) *FRC 154/2*	*Rx*	*Repair*	¼	
	(3)					(3)				
	(4)					(4) *TI 312*	*Rx*	*Check*	¼	
	(5)					(5)				
	(6)					(6)				
	(7) *Routines*		*1, 3, & 6 Monthly*	¾		(7)				
	(8) *Solenoid/ Alarm Checks*		*On Plant*	½		(8)				
	Notes									
T.E.L.	(1)					(1)				
	(2) *PRC 12–M*	*Rx*	*Remove*	¼		(2) *Misc. defects*			*1*	
	(3)					(3)				
	(4) *PRC 12–M*	*c/v*				(4)				
	(5)					(5) *LI 12-V*	*Tx*	*Repair –fit displacer*	¾	
	(6) *TRC 7–J*	*Rx*	*Remove*	¼		(6)				
	(7)					(7)				
	(8) *Routines*		*1, 3, & 6 Monthly*	*1*		(8)				
	Notes									
SERVICES	(1) *PRC 901*	*Rx*	*Calibrate*			(1)				
	(2)					(2) *Minor defects*			*1*	
	(3) *FM 903*	—	*Remove*			(3)				
	(4)					(4)				
	(5) *TC 6–W*	*c/v*	*Remove*			(5)				
	(6) *Routines*		1, 3, & 6 Monthly	*1*		(6)				
	(7) *F.M.'s*		*Readings*	½		(7)				
WORKSHOPS	(1) *FRC 110*	*Tx*	*Complete o/h*	*1*		(1) *Fabricate 50 thermo couples —standard 2 ft*			*2*	
	(2) *PRC 108/2*	*Rx*	,, ,,	*1*						
	(3) *TRC 7–J*	*Rx*	,, ,,	*1*		(2)				
	(4) *PRC 12–M*	*c/v*	,, ,,	*1*		(3)				
	(5) *FM 903*		,, ,,	½		(4) *M/c Orifice plate*		*FR 901*	*1*	
	(6)					(5) *M/c Carriers*		*FR 901*		
	(7) *TC 6–W*	*c/v*	,, ,,	½		*Construction order*			*1*	
	(8) *S.V. 311*	*s/v*	,, ,,	*1*		Engraving			*1*	
	Notes					Safety valves		*o/h stock*	*1*	
						Press gauges		,, ,,	*1*	
	Inspect spare Serial Nos. E.	*Hg manometer 4605 or*	*7903. Calibrate for*		*plant*	*issue.*				

C.v. = Control Valve Tx = Transmitter Cx = Controller Rx = Receiver

Table 3

No. 5651

INSTRUMENT SERVICE REPORT

Instrument Type: Receiver Controller — Date (Received): 7-9-60 (Completed): 10-9-60
Maker: Foxboro — Serial No.: E 39668.
Range (Previous): 3-15 psi — Application No. (Previous): ERC 516
Range (New): 3-15 psi — Application No. (New): ERC 516

CHECK		REMARKS	CHECK		REMARKS
Chart Drive	✓	Replaced.	Standardisation		
Linkage	✓	Cleaned	Burn-Out		
Case and Door	✓	"	Galvo.		
Pen/Pointer Ass.	✓	"	Control Action		
Element	✓	"	Mech. Wear		
Painted	✓		Alarm Action		
			Contacts		
Pneumatic Relay	✓	Cleaned	Valve Diaphragm		
Flapper/Nozzle	✓	"	Body		
Reducing Valve	✓	"	Seating		
Transfer Switch	✓		Gland Packing		
Index Alignment	✓		Lubrication		
Prop. Alignment	✓		Gaskets		
Proportional Action	✓		Positioner		
Intergral Action	✓		Stroke		
Derivative Action			Range		
Pneumaticet/Alarm			Pressure Test		
Press Alignment			Float and Tubes		
Reducing Valve			Check Valves		
Measuring Diaph.			Gland (Friction)		
Re-Action Diaph.			Gland (Packing)		
Safety Valve			Manifold Valves		
3-15 p.s.i. Output			Pressure Test		

CALIBRATION. (*Attach Section of Chart*)

ASCENDING				DESCENDING			
RANGE	RDG.	ERROR	% ERROR	RANGE	RDG.	ERROR	% ERROR
20%	5·4 psi	—	—	20%	5·4 psi	—	—
40%	7·8 "	—	—	40%	7·5 "	—	—
60%	10·2 "	—	—	60%	10·2 "	—	—
80%	12·6 "	—	—	80%	12·6 "	—	—
100%	15·0 "	—	—	100%	15·0 "	—	—

ARCING CHECK ☑ MAX. ERROR ± — % TALLY ATTACHED ☑

REMARKS. Stripped + cleaned. M40 unit - Cured up.
- New reset bellows - fitted.
- Calibrated - 2nd pen (PR 205) - No Errors

Overhauled by L. Bovey. Calibrated by R French. Passed by R. L Roberts

(483) L.12.54.

and takes priority over the former. The 48-hour period is found sufficient for the complete overhaul, re-calibration and painting of the vast majority of jobs, but in exceptional cases the instrument may be returned to the plant to give limited service whilst awaiting the delivery or fabrication of a special spare part.

In such cases a Service Report (see Table 3) is endorsed to enable the central records clerk to re-call the instrument when the spare is available. This service report is also used to compile a dossier of overhauls and modifications carried out on every instrument from the date of its installation on the plant.

Costs

The capital cost of installing and equipping the workshop that has been described is approximately 6% of the total factory capital expenditure on instrumentation. On the same basis, operating costs are calculated to be about 4% per annum and it is interesting to note that labour charges account for about two thirds of this amount.

So far, all revenue workshop costs have been charged to instrument accounts on the originating process centres, and no attempt has been made to correlate costs with instrument make, type, or function. This information will be useful in the selection and design of future schemes, however, and will be collected when workshop " times " become more stable.

Acknowledgement

Acknowledgement is due to The Associated Ethyl Co. Ltd. for permission to publish this paper.

(*Continued from page* 567)

The Directory of Opportunities for Qualified Men. *Cornmarket Press Ltd.* 1961. 155 *pp.* 8*s.* 6*d.*

This edition of the Directory of Opportunities for Qualified Men shows that the demand among industrial companies is greatest for mechanical engineers. The next in demand are physicists, then electrical engineers and chemists.

The preface is written by Sir Cecil Dannett, vice-chairman of A.E.I. Ltd. There are short articles surveying the demand for executives, opportunities abroad, opportunities for qualified women, and the hospital service, and a list is given of short full-time courses for qualified men and women.

The reference section, which forms two-thirds of the directory, lists companies, their work and the opportunities they offer.

Report of the International Commission on Radiological Units and Measurements. (*ICRU*) 1959, *National Bureau of Standards Handbook* 78 (*supersedes Handbook* 62), *issued* 16*th January*, 1961, 90 *pp.* 65 *cents.*

This Report of the International Commission on Radiological Units and Measurements supersedes the 1956 report which was published as National Bureau of Standards Handbook 62. The present Handbook, approximately twice the size of the 1956 report, provides increased coverage in the areas of clinical application and the physical aspects of dosimetry. Attention is also directed toward the present status of agreement between the national standardising laboratories in the fields of radionuclide and X-ray measurements. More detailed tables and graphs of data needed for dose determination from physical measurements are included.

The aim of much of the work of the ICRU, as this Report points out, is to improve the accuracy of the evaluation of absorbed dose in all places of interest in a patient or other objects. It is the view of the Commission that, for comparisons of biological effects, the absorbed dose should be known as accurately as possible and the limits of accuracy should be estimated.

Material in Handbook 78 is divided into three parts. Part 1, General Considerations, consists of a definition of terms, such as quantities and units (absorbed dose, gram rad, roentgen per millicurie hour, etc.), and relative biological effectiveness, as a recognised symbol in the field. Part II discusses clinical and biological applications, and Part III, physical aspects of dosimetry.

Order from Superintendent of Documents, U.S. Government Printing Office, Washington, 25, D.C.
Foreign remittances must be in U.S. exchange and should include an additional one-fourth of the publication price to cover mailing costs.

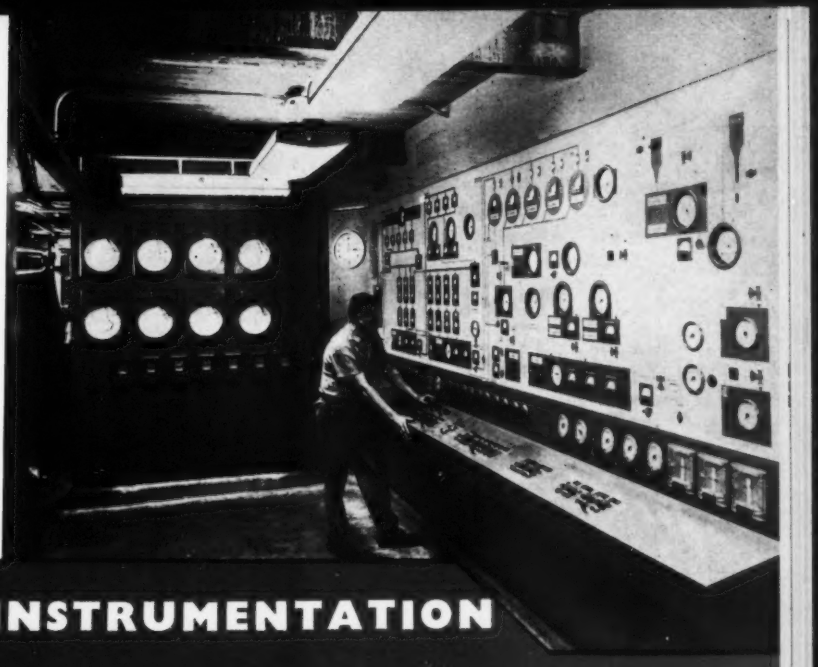
X-Ray Protection Up to Three Million Volts. *National Bureau of Standards Handbook* 76 (*supersedes H*60) *prepared by Sub-committee* 3 *of the National Committee on Radiation Protection and Measurement. Issued February*, 1961. 52 *pp.* 25 *cents.*

This Handbook sets forth standards of safety established by Sub-committee 3 of the National Committee on Radiation Protection and Measurement. It contains data and recommendations pertaining to all persons involved, including the manufacturers of the apparatus, designers and builders of the rooms housing it, the individuals in charge of installations, and the persons actually using the equipment.

Basic requirements as to safety standards are essentially the same in this Handbook as in its immediate predecessor, Handbook 60. Tables have been revised to conform with the new lower maximum permissible dose (MPD) adopted by the NCRP in 1957, and the differences in the maximum permissible doses allowed in controlled areas and their environs. Recommendations have been altered, deleted, or added as necessary to cover situations created by recent technical advances in machine design and by the development of new radiological techniques.

However, according to a statement made by the Sub-committee in the preface, the philosophy remains as it was originally expressed by the Committee 30 years ago, namely, that unnecessary radiation exposure should always be avoided and all exposure held to the minimum compatible with practical clinical requirements.

Order from Superintendent of Documents, U.S. Government Printing Office, Washington, 25, D.C.
Foreign remittances must be in U.S. exchange and should include an additional one-fourth of the publication cost to cover mailing.



Control console (Honeywell Controls Ltd.) for high-yield pulping system, a new semi-chemical groundwood process for pulping which uses extensive instrumentation. (Reproduced by permission of the Belgo Division of Consolidated Paper Corp. Ltd.)

By HUGH C. McINTYRE, M.A., M.C.I.C.

INSTRUMENTATION IN THE CANADIAN PULP AND PAPER INDUSTRY

A survey of instrumentation used in the industry at present indicates the great discrepancy between the amount of instrumentation in modern automated mills built during the past ten years, and the comparatively crude systems in the older plants. A particular examination is made of the number and extent of installations of closed-loop systems utilising pH and redox potential sensing elements in the paper industry. Two new continuous pulping systems rely heavily on increased instrumentation for their effectiveness. In view of current activity, there is no doubt that the next few years will see a great increase in the investment of Canada's pulp and paper activity in instrumentation.

DURING the past year the output of the Canadian pulp and paper industry once again exceeded all previous records, rising to £540 million.

Unlike people in some other segments of Canadian industry, pulp and paper manufacturers face the coming year without misgivings as to declining markets. In fact, three new mills are scheduled to go into production in 1961, and several expansions are under way—the largest building programme in the industry for some years.

Rising costs, both in forest and mill, are the main current concern in the industry. Mechanisation and automation, with all the instrumentation implied in these two trends, are being looked to as the solution to the cost problem. Productivity has risen 50% since 1949, but wages and other costs have kept pace.

In the past dozen years, the typical new mill has changed from one in which only the crudest instruments were used to one in which, especially in the pulping process, continuous production is achieved by the same complex of electronic and pneumatic controls seen in the modern chemical and petroleum plants. However, while this is true in the newer mills, the industry as a whole still has a long way to go, as a recent survey completed by the Canadian Pulp and Paper Association (CPPA) shows.

Instrumentation in the Industry

This survey was the work of the CPPA's Process Instrumentation Committee, a group only formed in 1957. They had as their aim, aiding the industry to achieve sound and economical instrumentation and assisting interchange of instrument application knowledge. They began their work by asking questions: What do instrument departments in Canadian pulp and paper mills consist of? How many men do they employ? What are the qualifications and responsibilities? How many instruments do they care for? What shop facilities, equipment, and records are in use? These questions, and others, were embodied in a question-

TABLE I

Application (pH)	Existing Installations		Estimated Future Installations	
	Responses	Installations	Responses	Installations*
Paper Machine Furnish	61	162	22	48
Raw or Boiler H_2O Treatment	27	43	13	14
Bleach Plant Caustic Stage	11	20	12	14
Cooking Liquor Preparation	10	15	14	18
White Water Clarification	9	13	9	9
Bleach Plant SO_2 Stage	7	11	5	6
Condensate Purity Monitor	7	8	6	6
Waste Treatment	4	5	7	10
Black Liquor Recovery	2	3	1	1
Lignin Recovery	1	2	1	1
Digester Cooking Control	1	1	5	8
Special Pulp Washing	2	4	1	1
Zinc Hydrosulphite for Groundwood Bleach	1	1	—	—
ClO_2 Bleach Preparation	1	3	—	—
Bellmer Bleaching	1	11	—	—
Brine Treatment for Chloralkali Prod.	1	4	—	—
Groundwood Grinder Shower Water	1	2	—	—
Parchmenting Neutralising Wash	1	3	1	1
Felt Shower Water	1	1	—	—
Latex Compound Make-up	—	—	1	1
Unbleached Kraft Acidification	1	1	—	—
Yeast Plant Fermenter	1	2	—	—
TOTAL	151	315	98	138*
Application (Redox Potential)				
Bleach Plant Chlorination	21	30	16	18
Bleach Preparation	10	10	—	—
ClO_2 Residual Destruction	5	10	1	1
Oxidation Pond Monitoring	—	—	1	1
TOTAL	36	50	18	20*

*—A number of responses indicate application anticipated without an estimate of number of installations.

naire sent to nearly 100 Canadian mills. Fifty-eight replies came back (a 60% return) upon which was based a 31-page report published in June, 1959. The survey is unquestionably one of the most complete and revealing ever made on instrumentation within a single major industry.

The main results of the survey are summarised in Table 1. The term "instrument unit" used in the first column requires some explanation. This term was defined in the questionnaire as covering a controller, a single-pen recorder or indicator (each pen of multiple units counts as one unit), a transmitter, a valve positioner, or a valve motor. Pressure gauges under six inches diameter, stem and bimetallic dial thermometers, and control valves were not counted as units.

Interesting figures concerning the relationship between instrument units per ton and principal end product were revealed. The weighted average of this ratio between major industry product classifications went like this: specialty papers—3·62 instrument units per ton; bleached sulphite pulp—2·21; bleached sulphate pulp—1·86; dissolving cellulose pulp—1·83; newsprint—1·11.

The size of the industry's investment in instrumentation is indicated by the fact that replacement value of instruments and control systems in the average mill is close to £145,000, totalling £8,200,000 for the 58 mills surveyed (out of the 128 mills in Canada). The replacement values were calculated at £164 per unit, an average figure arrived at by a committee survey.

Plant Instrument Departments

The main attention of the survey, however, was concentrated on the organisation and personnel of plant instrument departments rather than on a census of hardware. In most mills, the department had the responsibility for maintaining all process instruments, whether electric, electronic, or pneumatic, while the electrical department maintained all electric power instruments. Maintenance responsibility for other trades was usually cut off at the instrument panel. Department supervisory authority seemed to rest equally with the control superintendent or the plant

engineer, apparently depending upon whether management considered process control or instrument maintenance of primary importance.

The idea of scheduled maintenance has apparently made only a partial breakthrough in the Canadian pulp and paper industry. Of the mills responding to the questionnaire, 38·6% used it, another 15·8% used it for some instruments, and 45·6% serviced their instruments only on demand or breakdown.

Another wide variation noted was in the work load on the instrument technicians. Two mills assigned no less than 600 instruments per man, others had ratios as low as 63 instruments per man. Although the largest mills usually had the highest ratios, this was not necessarily the case. One large newsprint mill had a seventeen-man department to take care of 1,850 instruments. There was a close correlation here between low instrument per man ratio and scheduled maintenance practices.

Instrumentation training was another area about which the questionnaire was concerned. Only 21 mills had an educational programme out of 56 which employed full-time instrument men. In most cases, the senior member of the department (instrument engineer or instrument foreman) was the trainer. However, men from 50 mills had attended courses given by equipment suppliers, and 28 made use of correspondence courses. Most surprising was the fact that only in 12 mills was there any instruction given to process operators about the instrumentation they used to help them do their jobs!

pH and Redox Potential Installations

Another recent survey, which included U.S. as well as Canadian mills, casts illumination on a specific area of instrumentation of considerable interest to the paper industry. The industry represents one of the most widespread users of pH and redox potential techniques as sensing elements for closed-loop automatically controlled processes. It is estimated that approximately 20% of all industrial pH installations in existence in North America are found solely within the paper industry. The industry probably also has the bulk of redox potential process installations compared with all other industries combined.

In view of this, a survey was recently made by James T. Dykes, of Howard Smith Paper Mills (Cornwall, Ontario, Canada) and T. J. Kehoe, of Beckman Instruments (Fullerton, California) of pH and redox potential installations in 110 pulp and paper mills, to which 81 responses were obtained. Results were given in the form of a paper read at a symposium on analytical instrumentation in Montreal, June, 1960, but have to this date remained unpublished. Their tabulation is set out in Table II.

In summary, 365 applications of pH and redox potential instrumentation were found to exist in 69 of the 81 plants responding, an average of 5·29 per plant. One plant reported no less than 18 installations, of which 16 were operating automatically controlled systems.

The originators of the survey were considerably concerned with maintenance difficulties, and the response to this part of the questionnaire showed that maintenance time for this type of installation varied from plant to plant in an extreme manner, from 15 minutes per week per system to 8 hours. It was obvious in some of these cases that the system was malfunctioning and required corrective action. An earlier survey on the same subject indicates that coating of glass electrodes is the most serious problem—no fewer than 73% of mills employing this type of equipment stated that it created a significant problem.

An equally wide variation of replies concerned maximum pulp density at which pH and redox potential installations could operate. While the bulk of the respondents gave an upper limit of between 2 and 4% two stated 1% or less to be the upper limit, while two more claimed successful use at up to 6%.

All in all, the earlier survey showed that only 10% of users considered that pH and redox potential instrumentation required excessive maintenance, 26% stated that the additional maintenance effort was justified by results, while the remainder (64%) were quite satisfied with performance, their ratings ranging from "useful and reliable" to "highly satisfactory without qualification". It would seem, therefore, from these results, that the Canadian pulp and paper industry offers an expanding and appreciative market for closed-loop control systems using the principles of pH and redox potential measurement.

Continuous Pulping

Another factor which promises large-scale increases in the amount of instrumentation required by the Canadian pulp and paper industry is the trend to continuous pulping. Two systems are at present competing for the market, the Swedish Kamyr process and the American Bauer continuous digester. So far, the Kamyr digester system is well ahead, with an operating installation at Hinton, Alberta, and no less than five others under construction in various parts of the country. The Bauer system is still confined to one pilot plant unit being tested by Howard Smith Paper Mills.

Quality and uniformity are the main benefits which the industry hopes to achieve by continuous pulping, as well as economy of labour. And the quality and uniformity are achieved by instrumentation. C. A. Tevebaugh, Kamyr's chief engineer, puts his company's instrumentation philosophy this way: "Controls make the difference between average quality and high quality. We have attempted to make the system as automatic as possible in order to obtain uniformity of product and reduce operating costs, and to this end we have located all the critical controls on an instrument panel so that one operator can run the entire system from this point."

With either type of continuous pulping process, a number of automatic pressure-temperature control systems are required, and with the semi-graphic instrument console panel liberally equipped with visual and auditory alarms one man per shift can run a unit which may produce 500 tons a day of pulp for paper. In view of the current activity, there is no doubt that the next few years will see a tremendous increase in the investment of Canada's pulp and paper industry in instrumentation.

TABLE II

Compilation of the most significant facts on instrumentation in Canadian pulp and paper mills

Mill Code Number	Total Instrument Units	Product (See Code)	Daily Tonnage	Instruments Units/Ton	Replacement $ Value of Instruments†	Total No. of Personnel	Instruments per Man*	Scheduled Maintenance	Inst. Dept. Area: Sq. Ft.				
									Office	Storage	Shop	Total Area	Shop Area per Instr.
1	3000	B	430	6·97	1,350,000	8	375	Part	90	540	540	1170	0·18
2	3000	HDE	655	4·58	1,350,000	11	300	Part	144	700	700	1544	0·23
3	2941	HEFC	425	6·93	1,323,450	7	420	Yes	153	728	670	1548	0·22
4	2367	IKE	730	3·20	1,065,150	12	237	Yes	81	104	675	857	0·28
5	2000	IJFC	1138	1·76	900,000	4	500	No	—	—	450	450	0·22
6	1850	ICF	1720	1·07	825,500	17	116	Yes	120	552	960	1632	0·52
7	1793	DG	255	7·1	806,850	6	299	Part	264	512	512	1288	0·28
8	1340	HIF	967	1·39	603,000	9	168	No	—	—	—	1052	—
9	1220	ID	1225	0·99	549,000	8	152	Part	225	450	450	1125	0·37
10	1204	D	275	4·38	541,800	3	602	No	—	—	451	451	0·38
11	1200	A	175	6·85	540,000	3	600	Part	—	160	160	320	0·13
12	1200	D	350	3·42	540,000	11	109	Yes	no data given				
13	1200	B	687	1·74	540,000	9	150	No	72	90	472	634	0·39
14	1200	IJ	830	1·45	540,000	4	300	Yes	238	534	370	1142	0·31
15	1120	ICM	1045	1·07	504,000	7	160	Yes	115	100	391	606	0·35
16	1100	IFC	640	1·72	495,000	5	220	Yes	—	168	234	402	0·21
17	1039	CDBF	730	1·42	467,550	4	346	No	—	90	121	211	0·12
18	1036	IFC	700	1·48	466,200	4	259	Yes	60	100	156	316	0·15
19	1025	B	400	2·56	461,250	6	170	No	100	100	750	950	0·73
20	940	IFJC	897	1·05	423,000	4	235	No	—	—	160	160	0·17
21	900	ICF	1020	0·87	405,000	11	90	Yes	88	480	858	1426	0·95
22	900	IFC	1160	0·77	405,000	11	90	Part	120	180	900	1200	1·00
23	875	IEK	778	1·13	393,750	6	146	No	—	99	658	757	0·75
24	850	IECH	1010	0·84	382,500	7	121	Yes	120	108	432	660	0·51
25	836	AB	570	1·47	377,400	9	105	Yes	—	—	600	600	0·72
26	825	IFM	610	1·35	371,250	3	275	No	—	200	322	522	0·39
27	750	IFC	400	1·87	337,500	3	375	Yes	20	72	180	272	0·25
28	715	ICF	627	1·14	321,750	5	178	No	144	200	360	704	0·50
29	709	ICFH	426	1·66	319,050	4	236	No	—	—	198	198	0·28
30	675	CD	275	2·46	303,750	4	169	No	—	160	550	710	0·81
31	640	G	440	1·45	288,000	3	213	Part	—	—	486	486	0·76
32	633	LM	190	3·33	284,850	2	316	Yes	—	—	155	155	0·25
33	620	IFC	385	1·61	279,000	8	77	Part	225	450	450	1125	0·72
34	600	G	245	2·45	270,000	3	200	Yes	120	240	450	810	0·75
35	563	K	270	2·09	253,350	4	188	Yes	88	58	210	356	0·38
36	550	IFM	550	1·00	247,500	3	200	No	36	—	558	594	1·00
37	550	IFC	800	0·69	247,500	5	110	No	200	230	110	540	0·22
38	500	A	—	—	225,000	5	100	Part	—	200	100	300	1·00
39	500	IFC	780	0·64	225,000	5	100	No	—	270	432	702	0·86
40	500	IFC	710	0·70	225,000	4	167	Yes	—	90	450	540	0·90
41	498	IFC	390	1·28	224,100	7	71	No	—	—	496	496	0·99
42	477	IFC	860	0·55	214,650	7	96	Part	168	190	294	652	0·61
43	445	B	220	2·02	200,250	3	223	No	—	1600	800	2400	1·80
44	420	D	215	1·95	189,000	3	210	Yes	—	88	160	248	0·38
45	400	IFC	400	1·00	180,000	5	100	Yes	—	—	450	450	1·13
46	389	GD	240	1·62	175,050	2	389	Yes	—	—	432	432	1·12
47	342	IFC	220	1·55	153,900	2	171	Yes	80	—	120	200	0·35
48	318	IFC	410	0·77	143,100	3	159	No	—	—	180	180	0·18
49	317	IFC	710	0·45	142,650	5	63	No	—	96	320	416	1·00
50	304	IFC	460	0·66	136,800	5	101	Yes	150	—	380	530	1·26
51	304	CH	170	1·79	136,800	1	304	No	—	—	144	144	0·48
52	300	B	200	1·50	135,000	2	150	No	—	—	80	80	0·27
53	232	IFC	470	0·49	104,000	2	232	No	—	—	360	360	1·55
54	175	H	21	8·35	78,750	1	175	No	—	—	—	—	—
55	165	IFC	495	0·33	74,250	1	165	No	—	—	90	90	0·54
56	151	F	97	1·56	67,950	1	151	No	—	—	—	—	—
57	18	H	21	0·86	8,100	0	—	—	—	—	—	—	—
58	5	F	39	—	—	0	—	—	—	—	—	—	—

CODE TO PRODUCTS MADE: A—Sulphate Pulp; B—Bleached Sulphate Pulp, C—Sulphite Pulp; D—Bleached Sulphite Pulp; E—Kraft Paper; L—Corrugated Board; M—Hardboard.

**Instrument engineers, where employed, are not included in this calculation.* †*Value given in American dollars.*

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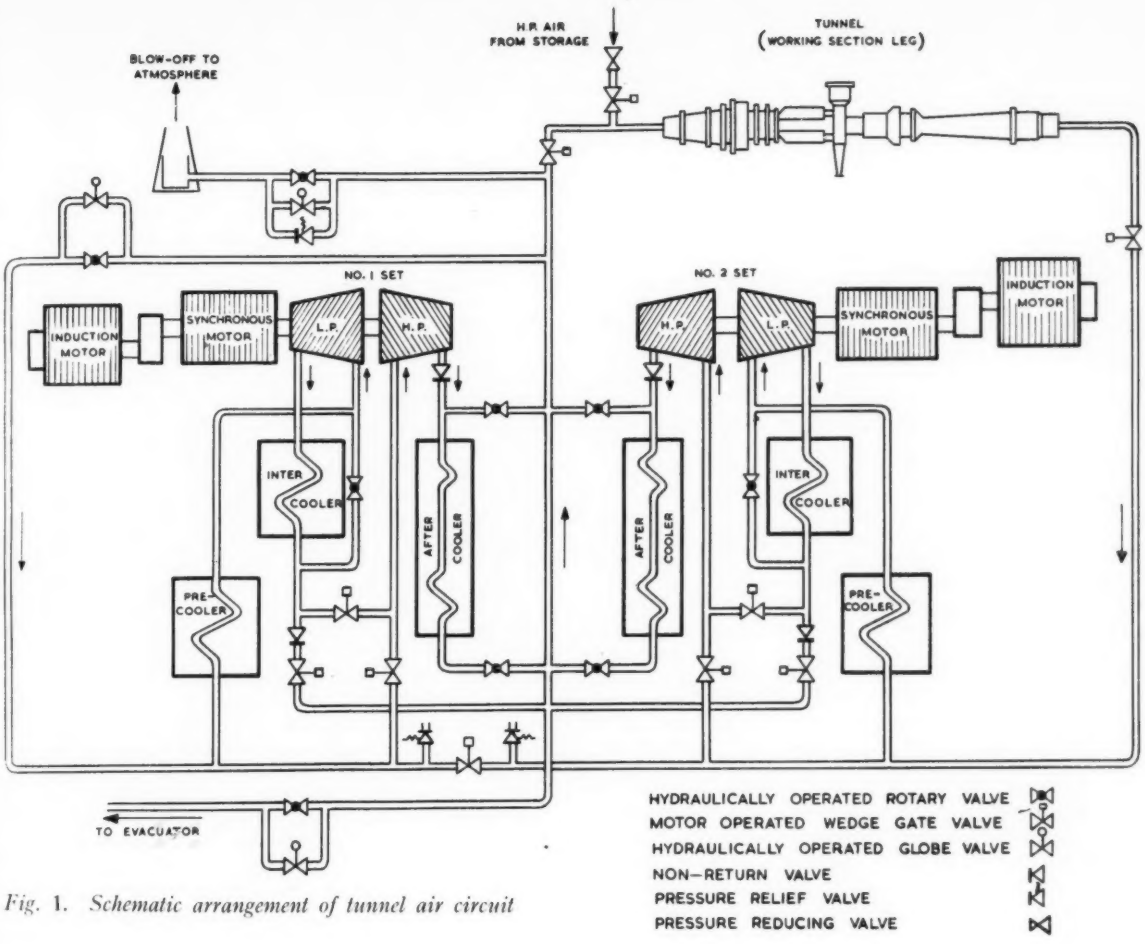


Fig. 1. *Schematic arrangement of tunnel air circuit*

High Supersonic Speed Wind Tunnel

Introduction

THIS new installation at the Royal Aircraft Establishment, Bedford, is complementary to the 8 ft × 8 ft high-speed tunnel which was opened in 1957. Its purpose is to provide a continuous closed circuit tunnel for tests on models over a Mach number range of 2·5 to 5·0 in a working section 4 ft high by 3 ft wide. It uses inlet total pressures up to about 12 atmospheres (about 176 lb/in²) to achieve high Reynolds numbers, and air temperatures up to 150°C to avoid liquefaction effects at the upper end of the speed range.

The tunnel air circuit comprises a working-section leg, compressors, coolers and a system of pipework and valves necessary to complete the closed circuit and to permit the compressors of each set to be operated either in series or parallel according to the characteristics required. The working-section leg is over 150 ft long and involves the inlet and contraction sections, nozzle, bridle structure, model-support section, supersonic and subsonic diffusers and outlet section.

Before considering the working-section leg and its instrumentation it may be of interest to examine the air circuit system. This is indicated in Fig. 1.

Compressor Plant

Each compressor set has a low pressure (L.P.) axial flow compressor having a pressure ratio of 4·35 and a volume flow of 208,500 cubic feet of air per minute at 40°C inlet temperature. In addition, there is a high-pressure centrifugal flow compressor (H.P.) having a pressure ratio of 3·7 and a volume flow of 49,800 cubic feet of air per minute at 40°C inlet temperature. When the two compressors are connected in series there is an overall pressure ratio of 17 to 1.

The motive power for each set is primarily provided by a 34,000 hp synchronous motor designed to run at a fixed speed of 3,000 rev/min when connected to the grid, or at any speed between 2,160 rev/min and 3,000 rev/min when connected to the Establishment's gas turbine driven generators.

For starting purposes, and to provide an additional 10,000 hp, a wound-rotor induction motor drives the compressors through a speed-increasing gearbox. This induction motor is controlled by a large continuously rated liquid regulator.

The sets can be brought to rest extremely quickly by means of a dynamic braking system. It is not normal to use dynamic braking on motors fitted, as these are, with differential protection, as this causes permanent unbalance of the differential protection current transformers. This difficulty has been overcome by the use of a specially designed switching system.

Associated with the compressors, in Fig. 1, a pre-cooler, an inter-cooler and an after-cooler will be observed. The function of these is described below.

Pre-coolers

The function of each pre-cooler is to cool the total inlet volume flow of the L.P. compressor at inlet pressures between 0·5 and 14·7 lb/in² absolute from temperatures as high as 150°C to 40°C at inlet to the compressor. For this duty an extended surface water-through-tube type of cooler is used, the air flowing in a single pass across banks of gilled tubes arranged within a fabricated steel pressure shell of rectangular cross-section.

Inter-coolers

The inter-coolers are generally of similar construction to the pre-coolers and cool the air delivered by the L.P. compressor from 240°C to 40°C before entry to the H.P. compressor. In this case there are twelve separate removable tubed elements.

After-coolers

The duty of the after-coolers is to cool the air received from the H.P. compressor at 245°C to 40°C before delivery to the working section of the tunnel. Air by-pass and mixing arrangements provide a quick response method of controlling the temperature of the air delivered to the working section at any desired constant value between 150°C and 40°C.

By-pass Sections

A 60 in. diameter by-pass line, controlled by a full bore, fast-acting valve of the rotating plug type and by a smaller gate valve for fine control, is connected in parallel with the working-section leg. This by-pass line has four major purposes. Firstly, it permits matching of the compressor plant characteristics to the tunnel requirements at the upper end of the speed range. Secondly, it permits the compressor plant to be kept in operation while the working-section leg is isolated and opened up for access to the model, thus greatly reducing the loss of operating time caused by this operation. Thirdly, it permits the compressor plant to be run up to speed without establishing supersonic flow in the working-section leg. Rapid closing of the 60 in. by-pass valve then results in the establishment of supersonic flow in the shortest possible time, the shock wave front being driven rapidly downstream past the model with the minimum risk to it. Fourthly, the existence of the by-pass incorporating a Venturi meter throat has permitted the testing and evaluation of the compressor characteristics while the working-section leg was still under construction.

Another by-pass line with control valve is provided in parallel with each after-cooler so that the temperature of the air delivered to the working-section leg can be conveniently controlled over the range of 40°C to 150°C.

Air Drying

The tunnel performance required demands maintenance of the humidity of the air in the circuit at a very low value, a dewpoint below −50°F or a moisture content of less than 0·00005 lb of water per lb of air being the desired value.

The method adopted to achieve and maintain this low moisture content involves purging moisture already in the circuit by cycles of evacuation followed by recharging with dry air and packing all glands, seals and joints in the circuit with dry air at a pressure just above atmospheric to preclude inward leakage of moist air.

For this purpose air is dried to reduce the moisture content to less than 0·00002 lb/lb (dewpoint below −70°F) by compression to 4,500 lb/in² followed by after-cooling with brine to 40°F. There are two compressor sets allocated for this purpose capable of producing 300 lb/min of air at 4,500 lb/in².

Dry air is stored at the pressure of 4,500 lb/in² in sufficient quantity to permit rapid purging of any moisture in the air in the circuit. One advantage of this arrangement is that the time required to achieve the desired dewpoint in the circuit becomes a function of only the capacity of the evacuator plant. With a powerful evacuator plant, capable of evacuating the circuit to an absolute pressure of 1/10th of an atmosphere in 4 minutes, the moisture initially in the circuit can be removed in about 20 minutes. Thus, loss of operating time after opening the circuit to the atmosphere is reduced to a minimum.

The maximum rate at which the pressure level in the circuit can be increased by admission of dry air from storage when the compressors are running is governed only by the permissible rate of increase in demand for electric power which is limited to 10 MW per minute.

Compressor Plant Instrumentation

Control of the main compressor plant with its auxiliaries and associated air and cooling water valves is centred in a soundproofed plant control room overlooking the compressor bay and adjacent to the tunnel observation room.

Controls, instrumentation and fault indication associated with the starting, synchronising, running and stopping of the main compressor sets are grouped on a control desk.

Controls for auxiliary equipment and valves together with instrumentation and indication associated with them are mounted on a twelve-panel control board.

Before the compressor sets can be started a number of essential auxiliary services and valve positions must be correctly established to complete the starting interlock

circuits. These include ventilation fans for motors, oil, cooling water and electrolyte flow, emergency oil tanks full, air valves used for circuit selection and control purposes correctly set, liquid controllers in "start" position, changeover switches for dynamic braking of induction motors in "run" position and circuit evacuated. All air circuit selection valves are set in the correct position for series or parallel operation by a single selector switch. The state of each of these services involved in the starting sequence is displayed on a starting sequence annunciator panel.

Valve positions are indicated by "open" and "shut" lamps in the case of valves used for circuit selection and by scaled position indicators in the case of air control valves. These indications are incorporated in a mimic diagram of the air circuit.

Remote control of valves connecting the circuit to the dry compressed air storage system, to atmosphere and to the evacuator plant provide for adjustment of the total pressure at compressor delivery between the limits of 1·5 and 180 lb/in² absolute. Similarly, remote control of valves by-passing the after-coolers provide for the adjustment of air temperature between the limits of 40°C and 150°C and valves in the main by-pass line control the flow of air to the working-section leg. Arrangements are provided to transfer the controls for these valves to the tunnel control desk in the observation room on which the control valve position indicators are repeated.

Abnormal conditions or faults for which instant shut-down is not imperative throw up an alarm on an annunciator panel on the plant control desk and also operate an audible alarm. These include such conditions as high winding temperatures, high lubricating oil, cooling water or tunnel air temperature, low cooling water flow, excess out-of-balance in rotor currents of induction motor or critical slip frequency.

Conditions which admit of no delay such as a hot bearing, lubricating oil flow failure, electrolyte flow failure, excessive induction motor out-of-balance currents combined with critical slip frequency, or fault conditions in the windings of the compressor driving motors, result in automatic tripping.

On the control desk in the observation room a push-button is provided for normal shut-down of the tunnel. This initiates an automatic sequence of valve movements which reduces the pressure in the circuit at a controlled rate to below 5 lb/in² absolute and then opens the main by-pass line, after which the compressors can be shut down without endangering the model.

An emergency stop button is also provided for use when an instant-shut down is imperative. This simultaneously jettisons air in the circuit to atmosphere and trips out the compressors.

Liquid Controllers for Induction Motors

The design of the liquid controllers used in conjunction with the induction motors required special care to ensure that an almost exact balance of rotor currents could be achieved and maintained.

Each controller is capable of a continuous dissipation of 3,200 hp at an electrolyte temperature not exceeding 70°C and a circulation rate of 1,200 gal/min, the total electrolyte capacity being 2,000 gallons. Duplicate electrolyte pumps are provided, one acting as standby to the other. The standby pump is brought into operation automatically in the event of failure of the other pump. Heat is transferred from the electrolyte to cooling water in heat exchangers through which cooling tower water is circulated at a maximum rate of 275 gal/min.

Close temperature control is required to obviate changes of electrolyte resistivity and consequent change of load during normal running. Two sets of controllers are provided. One maintains a constant temperature of about 63°C for normal running conditions. The other comes into operation when the set is stopped and reduces the electrolyte temperature to 52°C in preparation for a restart. In order to prevent the temperature falling below 52°C during short shut-down periods, nine thermostatically-controlled 9 kW heating elements are installed in the electrolyte sump. Circulation of the electrolyte is maintained when the heaters are switched on.

The moving electrode system is precisely guided and is driven by a d.c. geared motor unit with potentiometric control of the armature to give the full travel of 42 in. from "resistance all in" to "resistance all out" in a period which is adjustable between 20 seconds and 2 minutes.

Balance of rotor currents within the target figure of 2% can be achieved and maintained without difficulty.

Control Valves in the Air Circuit

Control valves used for circuit selection purposes are of the wedge gate type and those used for control purposes are of the full bore rotating conical plug type which permit higher speeds of operation. Valves which may be subject to high pressures and temperatures have fabricated or cast steel bodies. The principal air circuit selection and control valves are hydraulically operated under the control of solenoid-operated pilot valves. Valves used for control purposes are fitted with four pilot valves which give the option of fast or slow operation in each direction.

Non-return valves are fitted at each compressor discharge branch to prevent reversal of flow when one set is running and one set stationary. Pressure relief valves are fitted to limit the pressure level on the inlet and outlet sides of the compressors to the maximum design figure.

Pressure-reducing valves maintain a pressure of 250 lb/in² at a point outside the tunnel for all reservoir pressures between 4,500 and 700 lb/in² and admission of air to the tunnel circuit is through a gate valve remotely controlled from the tunnel control room. A separate system breaks down the pressure to 250 lb/in² for distribution for dry air packing purposes.

Working-section Leg

The working-section leg of the tunnel circuit (Fig. 2) is 154 ft 6 in. long between the centre lines of the cascade bends at each end and comprises an inlet cascade bend, an inlet cone and settling chamber with screens, a contraction section, a movable wall nozzle with adjustable throat gap and wall contour, a model support section, an adjustable supersonic diffuser, an

outlet section with subsonic diffuser, catch net, and outlet cascade bends followed by a second catch net.

One of the principal design requirements has been to provide maximum availability of the tunnel for testing work. Since the rigging of a model with its instrumentation may take up a considerable period of time it must be possible for this work to be undertaken outside the tunnel circuit while tests are proceeding on another model. For this reason all arrangements for the mounting, manipulation and instrumentation of models are incorporated in a number of separate and interchangeable model support sections or trucks which can be quickly disconnected and removed bodily from the air circuit to an adjacent rigging bay.

Sections of this leg of the tunnel circuit both upstream and downstream of the nozzle section are arranged to travel on a system of rails accurately levelled and located on a grillage embedded in the concrete foundation. This arrangement provides for axial movement to accommodate expansion upstream and downstream from an anchor point at the downstream end of the nozzle. It also provides facilities for introduction or removal of the screens in the settling chamber and for removal or interchange of model support sections. A transporter truck running on another set of rails at right angles provides for transport of model support sections into and out of the tunnel circuit and for their transfer to any one of four sidings in the adjoining rigging room or to another siding under the crane in the main bay.

Instrumentation of the Working-section Leg

Control of the working-section leg of the tunnel is centralised on three desks in a sound-proofed observation room adjoining the control room for the main compressor plant.

On the left-hand desk are grouped controls for valves which are used for adjusting air pressure, flow and temperature or for normal or emergency shut-down of the tunnel. Indicating instruments provide information on valve positions and air conditions in the circuit. An annunciator panel provides information on the availability of essential services.

The centre desk accommodates the positional controls for the moving walls of the nozzle and supersonic diffuser and for the model. Indicators show servo error while the positioning systems are following up the instructions given by the controls. Indication of diffuser normal shock position relative to the supersonic diffuser throat is also provided.

Observation of the model can be made by a closed-circuit television system and a Schlieren system and the right-hand desk accommodates the TV and Schlieren displays and controls for these and their cameras.

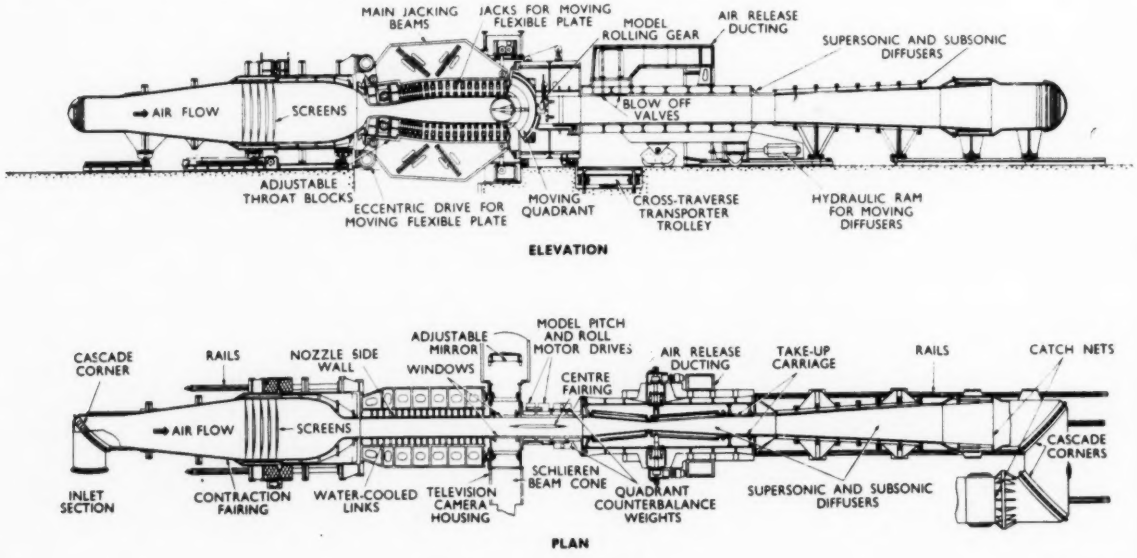
On another panel in the observation room instruments are provided to indicate the curvature of the flexible walls of the nozzle at each station together with remote controls for the corrector unit. The latter permits the introduction of any one of eleven preset corrections to the flexible plate position at any or all of the jacking stations. It also permits manual adjustment over the full range of correction available.

The nozzle controller together with the corrector unit is installed in a separate temperature-controlled room which is pressurised with filtered air to exclude dust.

Interlocks are provided to prevent danger through malfunctioning of the controls or negligence and to safeguard the flexible walls of the nozzle against accidental overstressing.

In the first category are included interlocks which prevent disconnection of the hydraulically-operated quick release bolts or unlocking and release of the interchangeable windows unless the circuit is at atmospheric pressure; other interlocks prevent retraction of the model support and downstream sections

Fig. 2. Working-section leg of Bedford wind tunnel



until the quick release bolts have been disengaged. Warning is given of failure of any of the bolts or windows to lock securely.

In the second category is a group of interlocks which freeze all nozzle controls in the event of curvature of the flexible walls exceeding a preset maximum, any of the positioning servos failing to follow its transmitter within a maximum tolerable error, or any break in a magslip chain or failure of its supply.

Fault interlocks are designed to fail to safety and to lock out for a fault condition, thus facilitating the location of a transient fault. Visual indication of the nature and location of faults is provided.

Flexible Plate Nozzle

The flexible plate nozzle is not yet incorporated in the working-section leg of the tunnel, but it will involve considerable instrumentation and is, therefore, described. Because of the conditions under which the tunnel will be operating several unusual features had to be adopted in the design.

The maximum inlet pressure will be about 12 atmospheres absolute and, to prevent liquefaction in the nozzle at the high Mach numbers, the temperature of the air will be allowed to rise to 150°C. Under some operating conditions the pressure in the tunnel may be below 0·1 atmosphere absolute. It was decided at an early stage that, with the high temperatures and high rates of change of temperature, coupled with the degree of accuracy required for the nozzle control devices, it would be inadvisable to enclose these devices within a pressure shell.

This decision introduced the difficult problem of providing a very efficient sliding seal between the fixed and moving walls of the nozzle. The double seal to be used for this purpose will be packed with dry air to prevent the ingress of moist atmospheric air into the circuit. This system of dry-air packing of all seals has already been employed on all joints in casings, and on all entries for drive shafts, etc., which penetrate the pressure shell.

Essentially the nozzle will comprise two fixed side walls and movable top and bottom walls. Each of the moving walls of the nozzle will be carried by a pair of extremely stiff fabricated steel beams pivoted at the downstream end. At the upstream end each pair of beams will carry a throat block of fixed contour which will be driven upwards and downwards to vary the throat gap. The variable contour top and bottom walls of the divergent sections of the nozzle will be formed by flexible plates each attached to one of the throat blocks at the upstream end and also to the supporting beams through 17 pairs of motor-operated ball screw jacks.

Nozzle Adjustment

The seventeen pairs of ball screw jacks employ preloading to eliminate backlash. The spacing between pairs of jacks varies from a minimum of 9 in. at the upstream to 14 in. at the downstream end. Each pair of jacks is driven through reduction gears by a 0·25 hp 1,000 rev/min separately excited direct current motor.

The motors controlling the throat gap and the plate jacks are each supplied by a separate variable voltage generator, the output of which is controlled by a positional error signal through a phase-conscious amplifier giving a push-pull d.c. output to the two separate field windings.

The input information for each station is set up by means of linear plate cams mounted on the surface table of the nozzle controller. For adjustment of the throat gap and wall contour this table is traversed under a head carrying devices to sense the ordinates of each cam. The sensing devices are magslip transmitters driven through precision cut racks and pinions by the cams. Similarly, magslip coincidence transmitters, mounted on unstressed beams above and below the moving walls of the nozzle, sense the position of the throat and flexible plate wall at each station. Any misalignment between the transmitters and the coincidence transmitters produces an error signal of amplitude which is a measure of the magnitude of the position error and of phase corresponding to the sense of the error. Follow-through magslips mounted on a corrector device somewhat similar to the nozzle controller provide for feeding in a number of predetermined or adjustable ordinate corrections for each station if required. Stabilisation of the servos is normally effected by transient velocity feedback, the velocity signal being derived from the armature of the motor driving the output member. All servos on the nozzel can be "frozen" when required by application of solenoid brakes to the driving motor shafts and opening of the servo loops.

A standard design of rack-mounted transistor amplifier is used for all servo position controls on the working-section leg, modifying units being fitted as appropriate to the output power requirements of the individual drives.

The positional setting accuracy aimed at in the design is a throat gap within 0·002 in. and flexible plate position at each jacking station within 0·001 in. of the nominal setting. Tests on a prototype jacking station with its servo controls give promise of a close approach to these targets.

At the designed speed of operation the nozzle setting can be changed from Mach 5 to Mach 2·5 in a minimum period of 2·4 minutes. The position of the table of the nozzle controller, which determines the setting, is controlled by another similar positional servo from a magslip transmitter calibrated in terms of Mach number on the control desk in the observation room. The rate of change of setting is adjustable.

Model-support Section

This is a structure on which the models to be tested can be conveniently mounted and manœuvred in the airstream. It consists of four fabricated sections bolted together to form a rectangular shell. The whole of the structure can be removed from the line of the tunnel and taken to an adjacent rigging bay on a motor-driven cross-traverse transporter, and another model-support section or the calibration section can be inserted in the tunnel. In order to remove such a section from the air circuit, all casings downstream of the nozzle are moved axially a distance of 11 ft thus positioning the model-support section over the transporter.

The main components of the model-support section are the moving quadrant and the sting carrier shaft on which the model is mounted.

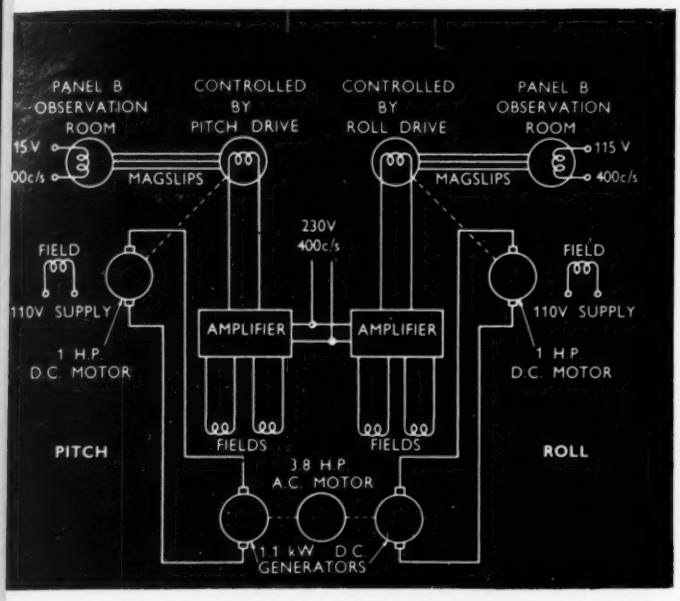


Fig. 3. Simplified electrical diagram for model pitch and roll control

The sting carrier shaft with its drive and supporting bearings is mounted in a moving quadrant of stainless iron weighing about $2\frac{1}{4}$ tons. This is driven by a pinion engaging with teeth cut in the back of the quadrant to give control of pitch angle between the limits of 5° depression and 27° elevation from the horizontal. The driving and servo positioning control give rates of change of pitch angle up to a maximum of 1° per second with a specified setting accuracy of ±0·05° at any point in the range.

The roll drive, through a gearbox mounted at the rear of the quadrant, can rotate the sting carrier shaft through an angle of ±180° at a speed which can be pre-selected up to a maximum of 2·5° per second with a specified setting accuracy of ±0·1° at any point.

Pitch and Roll Adjustment

Pitch and roll devices are driven by separately excited d.c. motors of 1 hp which are each supplied by a separate variable 1·1 kW d.c. voltage generator (Fig. 3). Both generators are driven by a 3·8 hp a.c. induction motor and each have two separate field windings which are connected to the output circuits of the positioning servo amplifier. The field windings are connected in such a way that the standing output currents produce opposing magnetomotive forces in the two windings. The desired setting of pitch or roll is set up on a magslip transmitter, in the observation room, calibrated in angles of pitch or roll. Any misalignment between the position of this transmitter and of a coincidence transmitter coupled to the driven member (the sting or quadrant) produces an error signal of magnitude and phase dependent upon the extent and sense of the misalignment. This is fed into a phase-conscious amplifier which unbalances the currents flowing in its output circuits through the two field windings of the generator. As a result of this the generator applies a voltage across the armature of the driving motor of the polarity required to drive the pitch or roll mechanism into coincidence with the position selected.

Rotating shaft position digitisers within the model-support section, each driven by a shaft in the gear train in close proximity to the quadrant or sting carrier, provide data for indicating and recording the angle of incidence and roll. These are of a new contactless design developed for this application to overcome difficulties experienced with digitisers of the segmental disc contact type under the high ambient temperature conditions. Each digitiser employs four magslip transmitters geared together in 10/1 chains. Each transmitter energises three mixing transformers, the secondary windings of which are interconnected to give five output voltages which vary with the shaft position. When phase-consciously detected, these outputs are used to provide two separate output codes to operate a four-digit display controlled by four M-type motors and a punched card recording and computing system.

Calibration Section

The calibration section is of generally similar construction to and mechanically interchangeable with the model-support sections. It is designed to provide facilities for exploring the flow pattern in the region in which the model is mounted. In place of the quadrant and sting carrier provided on the model-support sections it is fitted with a probe arm of wedge section and cruciform shape extending some 3 ft in a vertical plane which can be traversed some 6 ft in an upstream and downstream direction and laterally at right angles to the direction of flow. The probe arm incorporates seven pressure measuring heads. Movement of the probe arm is controlled by positioning servos, and data on its position is provided by digitisers, both of which are generally similar to those used on the model-support sections.

Contractors

The principal contractors for instrumentation and associated equipment mentioned in the foregoing description were:

Associated Electrical Industries Ltd.
Main compressors, motors, gears, coolers and control equipment.
Sub-contractors:
Horsley Bridge & Thos. Piggott Ltd.
Air circuit pipework.
Harland Engineering Co. Ltd.
Air circuit rotating plug valves.
J. Blakeborough & Sons Ltd.
Air circuit and cooling water gate valves.

The General Electric Co. Ltd.
Working-section leg comprising inlet and outlet sections, adjustable nozzle, No. 1 model-support section, calibration section, supersonic diffuser, servo positioning and sensing devices, controls and instrumentation.

Pye Ltd.
Closed-circuit television system.

Automatic Testing of Watt-hour Meters

Introduction

AN increasing demand for improvement in the accuracy of watt-hour meters, to ensure that they fulfil the requirements for certification under the Electricity Supply (Meters) Act, has led meter manufacturers to give considerable thought to methods of testing and calibration. From an economic aspect, since large numbers of meters are involved, it is necessary to employ some form of multiple testing in which the meters may be compared with standards of known accuracy.

Sangamo-Weston Ltd. have evolved a method of rapid yet effective automatic testing of large batches of meters termed TRACE. The method possesses extremely high accuracy and enables defective meters to be rejected quickly. An error band of 0·1% on heavy loads and 0·3% on light loads are the magnitude of limits of calibration.

Because of this high order of accuracy, some pre-calibration is introduced before submitting meters to the final accurate calibration of TRACE.

Pre-calibration

Pre-calibration is carried out in two stages. The first stage involves adjustment of the meters without their brake magnets, and the second stage with the brake magnets fitted in position.

Adjustments Without Brake Magnet

In this stage, the meters arrive from the assembly line on an endless belt system on to a special bench. The supply voltage is applied to the potential circuit only, and the light load adjuster is set to give balanced forward and backward movement of the disc at the anti-creep holes. In the absence of any magnet damping at this stage, the test becomes very sensitive and the adjustment brings the subsequent "as found" accuracy on the light load to within 2%, which is convenient for final calibration on TRACE.

Full load current at rated voltage and zero power factor is then applied and this condition is held automatically whilst the meter is being adjusted.

The master meter used in the next part of the test contains a disc with a shaped periphery over which is suspended a small induction coil connected to the tuned grid circuit of an oscillator. Any movement of the disc with respect to the coil will change the grid tuning and cause a variation of current in the anode circuit of the oscillator, which is connected to the d.c. control winding of a saturable reactor. The a.c. winding of the reactor is connected to a phase-shifting network which is associated with the master meter potential coil. Any change, therefore, in the phase angle between full load current and rated voltage in the meter circuit will cause the shaped disc in the master meter to rotate. This will alter the tuning of the oscillator and thus cause a variation in anode current, which will, in turn, vary the impedance of the saturable reactor. The reaction on the phase-shifting network will electrically balance the voltage supply to the master meter and meter under calibration, and will automatically restore the condition of 90° with respect to the load current. Since no mechanical device is used, electrical "hunting" is completely eliminated.

The inductive load adjuster on the meter under test is then set to give a standstill condition of the disc, and the subsequent "as found" accuracy of the meter on 0·5 power factor load when transferred to TRACE for final calibration is generally within 1%.

An oscilloscope test indicates the correctness of the meter assembly by showing a straight line trace. In the case of a faulty assembly, a Lissajous figure is produced on the oscilloscope screen, and its shape indicates the nature of the fault.

Adjustments with Brake Magnet

The second stage of pre-calibration is made on another bench and here the brake magnets are fitted. The meters are adjusted to within 1% on full load at unity power factor by means of a conventional stroboscope test.

A shadowgraph is used to give an enlarged view of the meter worm and train-register worm-wheel meshing, so that mechanical adjustment and trueness of rotation of the disc shaft may be checked accurately under full load conditions.

The meters are then transferred to another special bench where they are tested for at least one complete disc revolution at approximately 80% of the nominal minimum operating load (0·25% of rated current at rated voltage and unity power factor load).

The meters are then loaded on to another endless belt system which conveys them to the TRACE benches for final accurate calibration.

Test Recording and Calibrating Equipment —TRACE

The installation comprises 50 individual meter test stations situated above the moving belt system which brings the meters from the pre-calibration area. The meters are taken from the belt and loaded into the test stations by hand and, after calibration, are replaced on the belt, by hand, for conveying to the shipping station. All testing and calibration operations, however, are automatic. The test stations are arranged, for a variety of connections and a special spring-loaded

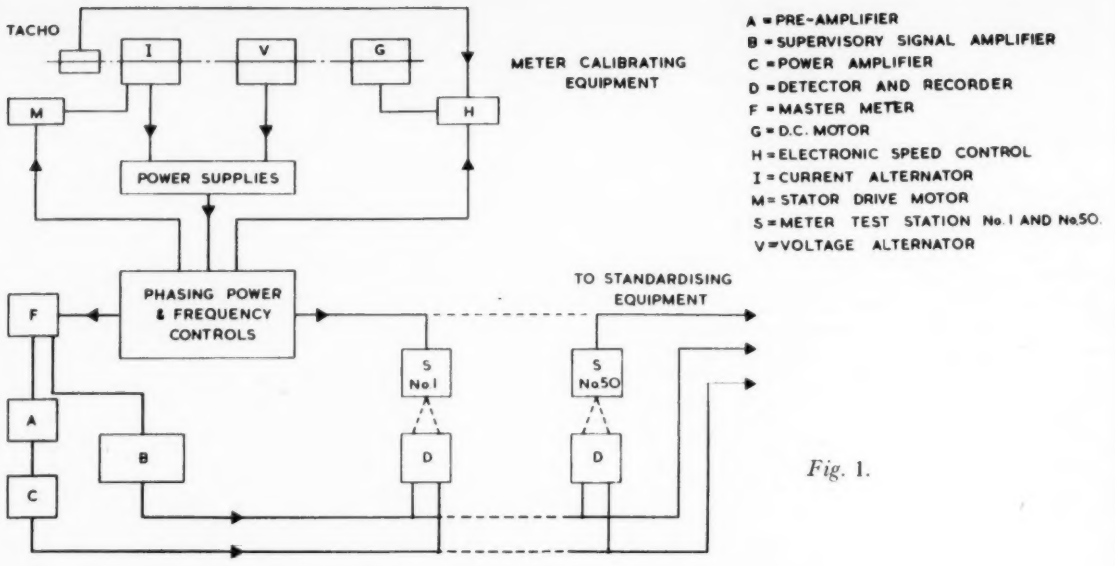


Fig. 1.

system ensures good electrical connections and rigid mounting.

TRACE itself consists essentially of a master control unit which is situated at the end of the line of 50 test stations. It controls the power supplies from two mechanically-coupled alternators and their associated control equipment and includes a master control meter which provides a calibrating means for the 50 meters undergoing test.

Master Control Unit

Power Supply Control

The power supplies used for meter testing comprise two single-phase 2·5 kVA alternators directly coupled to a 7·5 hp d.c. motor. An electronic control circuit regulates the power supply to the armature of the d.c. motor and so controls its speed and, hence, the frequency of the alternator outputs. The frequency range available is 35–70 c/s. The value can be observed on a meter in the master control unit and adjustments may be made to the frequency range by means of the remote controls on the unit which communicate with the electronic control circuit. The frequency, once set, does not vary with changes in load since the d.c. motor drive supply is stabilised by a tachometer generator feedback (Fig. 1).

One alternator supplies the current or series circuit and the other the voltage or shunt circuit. The position of the stator on the series alternator may be adjusted to produce a phase displacement between the two alternator outputs. The adjustment may be made manually by means of a handle directly geared to the stator, or electrically by means of a small three-phase motor remotely controlled from the master control unit. Coupled to the stator is a selsyn transmitter. A corresponding selsyn receiver is housed in the control unit and indicates, on a dial, the correct stator position.

The voltage supplies from the alternators are regulated by voltage-sensitive relays connected across the outputs. If, for example, the voltage exceeds a given maximum value, relays operate and cause the output from a motorised Variac to fall. The Variac controls the field excitation of the alternators so that a decrease in its output decreases the field excitation and causes the alternator output to drop. If the alternator voltage falls below a minimum value, a reverse sequence is initiated and the output voltage rises. The voltage-sensitive relays, however, do not operate in the range 238–242 volts, and the motorised Variac is stationary within this range.

The alternator outputs are fed into two "Regavolt" transformers via a distribution board in the master control unit. Currents in the series circuit are available from 0–100 amp and voltages in the shunt circuit from 0–240 volts.

Master Meters

The control unit contains master meters calibrated for 50 c/s or 60 c/s operation. Selection of the desired meter is made by a switch, and a signal lamp indicates which meter is in circuit.

The current coils of the master meters are supplied from the secondary of a current transformer. When the current is 1 amp, at unit power factor, the discs of the meters rotate at 40 rev/min. The secondary winding of the current transformer is tapped to give a tolerance of 1·5% in steps of 0·1% from the normal current value of 1 amp. The speed of the master meters may, therefore, be varied over this range and a special 31-way switch enables the variation to be carried out.

Each master meter has a normal drive element, but above the rotor is mounted a light-weight disc with radial slots cut in it at the periphery (Fig. 2). The slots allow beams of light from two lamps to fall on two photocells underneath the disc. An adjustable mechanical template above the slotted disc enables a 90° phase displacement to be effected between the two cell outputs.

Each output is fed into a pre-amplifier followed by a power amplifier. The principal feature of the amplification circuit is a double triode stage connected in push-pull fashion. In the anode circuit is a high-speed telegraph relay controlling, in turn, a heavy duty change-over relay. The latter introduces a "chopping" action converting a smoothed stabilised d.c. supply into a train of square wave pulses. The two series of pulses, so formed, are fed into a synchronous motor of the hysteresis pattern. One of these motors is installed at each test station. Following the circuit through, the frequency of pulses delivered by the photocells to the amplifiers must be proportional to the master meter disc speed since the number of slots is constant. The frequency of square wave pulses delivered by the change-over relays to the motor depends on this frequency, so that the speed of the motor is directly proportional to the speed of the master meter disc.

Meter Test Stations

Each master control unit controls 50 meter test stations. Each test station incorporates spring-loaded systems to ensure good contacts. Selection of current circuits is made by tapered plugs and circuits. For voltages, a selector switch is provided.

From Fig. 2 it will be seen that the synchronous motor, to which reference has already been made, drives a drum carrying a raised helix beneath a paper strip. A dot is printed on the paper by means of a printing bar, which strikes a typewriter ribbon between the paper and bar.

A light beam from a lamp is arranged to fall on the underside of the disc of the meter under test and a photocell receives the reflected beam. A black spot on the disc interrupts the beam during each revolution. The photocell output goes to a triode amplifier. When the black spot interrupts the light beam, the triode is biased back beyond the cut-off point, and a relay in the anode circuit operates. This causes a 250 volt pulse to be applied to the trigger grid of a cold cathode tetrode which then conducts and discharges a "tank" capacitor through a solenoid. The solenoid operates the printing bar on its forward stroke, and then inches the paper forward, by means of a ratchet arrangement, on its return stroke. When the black spot has passed, the photocell, amplifier triode and relay return to normal conditions ready for the next operation.

As the meter disc rotates continuously a succession of dots appears on the paper. Since the drum carrying the raised helix is rotated by the synchronous motor under the control of the master meter, the part of the helix under the printing bar at the moment of operation will depend on any error between master and tested meter. If a line is drawn through the succession of dots, the slope of this line to a normal line, vertically up the paper, gives the extent of the error. Calibration for direct reading, by means of a cursor or graticule on a scale, follows a tangent law. Thus, for small errors, such as 0·1%, very accurate measurements are possible and for meter errors within 1%, the readability of the slope line is to 0·05% accuracy.

Supervisory Control

A form of supervisory control enables constant checking to be maintained on the equipment.

On the underside of the master meter disc two black spots are placed 177–183 degrees apart. A light beam from a lamp falls on to the disc and the reflected beam is picked up by a photocell. The spots interrupt the light beam as the disc rotates and a relay sends a 250 V pulse to a second cold cathode tetrode in each test station. This discharges a second "tank" capacitor through a supervisory solenoid which operates the printing bar, but does not inch the paper forward. Two dots appear on the paper for each rotation of the master meter disc. The helix revolves twice for each master meter disc revolution, which means that the supervisory dots appear side by side on the paper. As the paper is inched forward under the action of the tested meter the dots form two parallel lines. Any deviation in the parallel lines indicates that the synchronous motor is running at twice or half normal speed due to incorrect setting of the voltage selector switch on the test station.

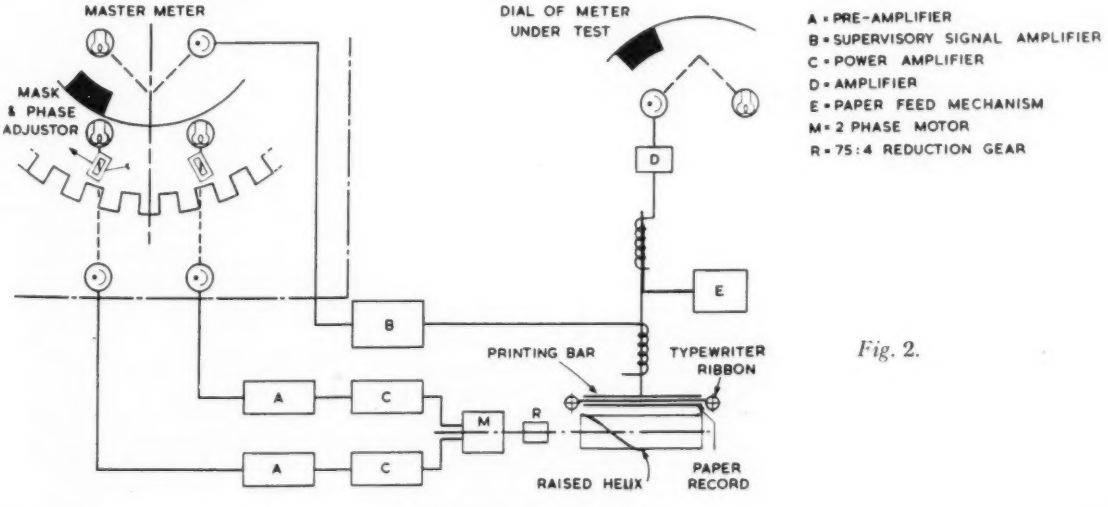


Fig. 2.

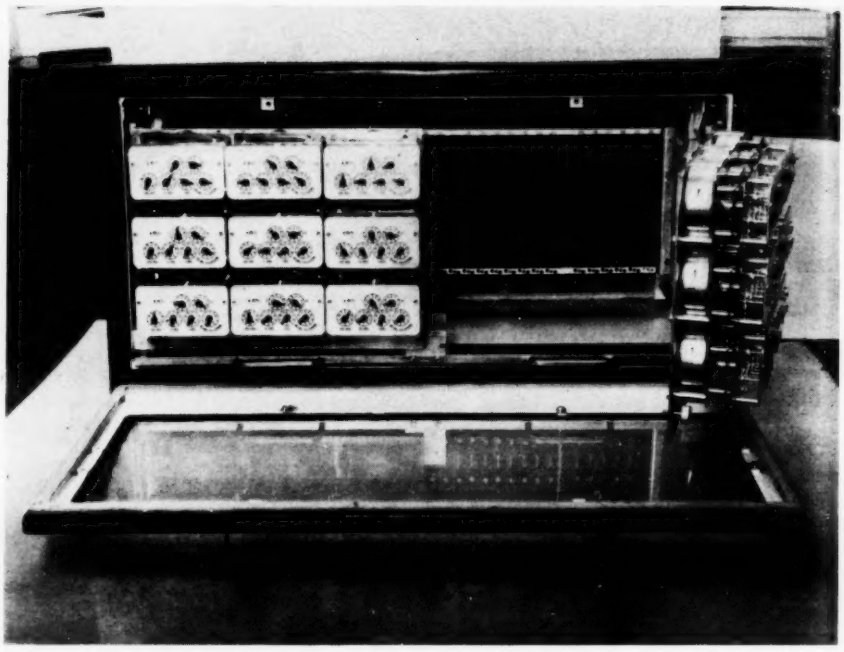


Fig. 1. The summation metering equipment is contained in a steel case 23 × 12 × 11 in. and accommodates up to 18 display registers, i.e. 16 inputs, 1 totaliser and 1 spare.

Electronic Summation Metering Equipment

THE main feature of the Ferranti electronic summation metering equipment for use in power stations, sub-stations and other bulk supply points is the replacement of electro-mechanical summation by electronic methods. The conventional mechanical contactors fitted to watthour meters are also replaced by photo-electric devices. The check and total registers are driven by an electro-magnetic stepping motor, hence the need for mechanical links such as contactors, ratchets, etc., has been obviated and mechanical maintenance, therefore, reduced to the barest minimum.

Although this new equipment may eventually supersede electro-mechanical equipment, it is completely compatible with it. In effect, the electronic equipment can drive existing electro-mechanical equipment and vice versa.

Function

The purpose of the summator is to register incoming pulses from a number of channels on check dials and to totalise the various pulses on a further register. It must also be capable of handling coincident pulses on any or all channels. Pulses as transmitted by a contacting device may be subject to contact bounce, and the summator must not therefore count any spurious pulses.

Basically, any electronic summator which achieves this must store incoming pulses as they arrive and clear each store in time sequence, the action of clearing a filled store can be made to give an output signal in time sequence.

The Ferranti electronic summator performs this function as follows.

Method of Operation

Essentially, a number of change-over switches are gated on each side by a sequential scanner, the outputs from the gates operating a bi-stable flip-flop. Thus a change in sense of the switch will cause the flip-flop to change state (or be " set ") on the arrival of the succeeding scanning pulse, and will be " reset " only after a further change in sense of the switch at the appropriate scan period. An impulse-driven stepping motor (which advances one digit on each reversal of current drive), having a centre-tapped energising coil, functions as the load of the flip-flop. Thus each pulse from the meter is registered in the check dial. Furthermore, the output of the flip-flop is differentiated (and rectified to produce unidirectional positive pulses) and transferred into a common highway to a totalising register. It should be seen that as a flip-flop can change state only when being scanned, the highway pulses will appear in time sequence. The totalising register

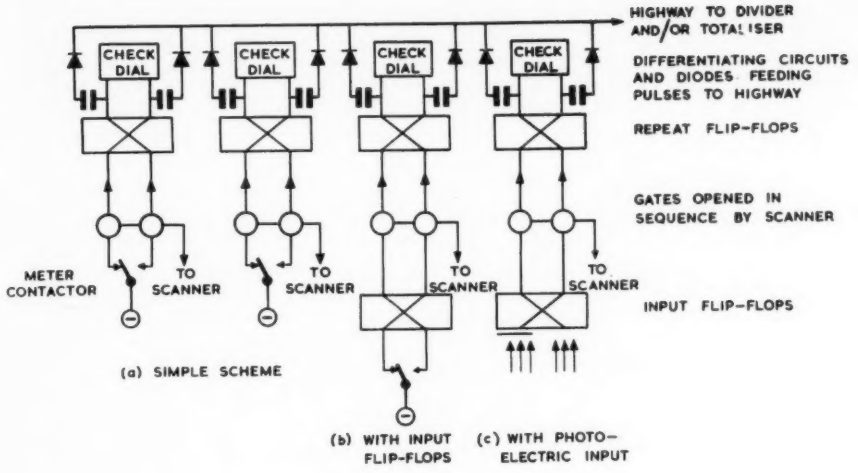


Fig. 2. Principle of operation of the metering equipment

consists of a binary counter, the load being the two halves of a stepping motor coil. Thus each pulse injected in the highway causes a change in state of the binary counter, and with it a record of pulses on the dial. (Fig. 1.)

It will be appreciated from the above that pulses are transferred into the highway, only during scan pulse periods, and that the rate of impulsing of the totaliser motor is equal to the scan frequency $\times$ number of channels (i.e., scan frequency defined as rate at which a particular channel is sampled).

The simplified system as described would require the impulse-sending contacts to remain closed for an appreciable time, in particular during sampling, or alternatively, an extremely high scanning rate, to ensure that incoming pulses are gated. This is avoided by initially storing the state of the change-over switch, in a further bi-stable circuit, and then gating the outputs of this bi-stable store by the scanner. (Fig. 2.)

Coincident pulses, like any others, would be stored in the input flip-flops and sequentially scanned. By its very nature, a double sensing system eliminates the effects of contact bounce, the flip-flop merely sets itself on the first make, ignoring subsequent rebounds, and resets only on a change in sense of the impulsing switch.

Sequential scanning is performed by decoding the outputs of a cascade of binary dividers, driven by a master multivibrator making a maximum of sixteen states. It is felt that sixteen channels is adequate for most summation schemes, this also affords a measure of economy.

The decoders and the gates as shown in the simplified schematic are combined in a single circuit. Thus, at any particular state of the binaries, one only of the sixteen channels is selected. However, there is still the possibility of adjacent scan pulse edges coinciding with the incoming pulse edges on both channels, in which case the totalising binary register would be unable to resolve them as two separate pulses. For this reason, the decoding arrangement has virtually five binary dividers in cascade, the alternate states, sixteen in all, being decoded. Thus one clear pulse width exists between adjacent scan pulses, eliminating the chance of unresolved pulses being lost. (Fig. 3.)

The scanner is analogous to a rotating switch having 16 contacts, with a clear break before make. It will be seen that the highway pulse rate will be scan frequency $\times$ 16 where two channels are adjacently placed. Division of the highway pulses by a suitable ratio may be necessary in many instances to keep within the limits of the totalising motor.

Photo-electric Switch

Where other forms of impulse senders are used, for example, photo-electric, further simplification becomes possible. A double-sensing photo-electric switch consisting of two photo-transistors in a bi-stable flip-flop configuration, can replace both the mechanical contacting switch and the initial flip-flop. The photo-transistor flip-flop is triggered from one stable state to another by exposing each photo-transistor in sequence to a light source by means of a pair of rotating shutters, adequate margins prohibiting simultaneous exposure of both. Light bounce is of no consequence in a flip-flop, as mentioned previously.

Net Power Indication

Where it is necessary to indicate net power (i.e., negative channels), this facility can also be provided by electronic means. The circuit consists of a reversible binary counter with a store capacity of four or more,

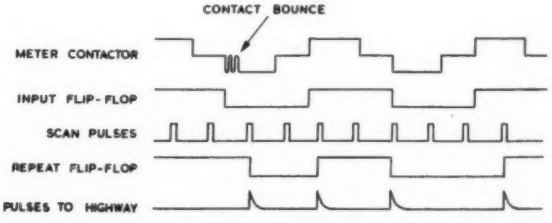


Fig. 3. Pulse shapes from input to output.

and associated logical gating. The reversible counter is itself a device that can increase its contents by one (counting in a positive sense) or decrease it by one (counting in a negative sense) depending upon which of its inputs is pulsed. The two highways, generated power and auxiliary power, for example, feed each of the two inputs. Under normal loading conditions the generator pulses, which come at a higher rate, are routed to a net generated register by means of gates operated by the reversible counter. Under light load, where the reverse situation may take place for short periods, incoming auxiliary pulses will be held in store, until subsequent generator pulses cancel them, after which the generator pulses are routed once more to its net register. Should the auxiliary pulses fill the store, further pulses may be routed to a net auxiliary register if desired. The gross totals could be recorded if required.

Summator

The entire summator is transistorised, all the circuit functions being provided in printed card form. The whole is contained in a case measuring 23 × 12 × 11 in. which includes the printed card container at the rear, with the register dials situated in front. These are mounted on hinged plates to permit easy access to the cards. A total of eighteen registers can be fitted on the panels, and where fewer channels are used a maximum demand indicator can also be accommodated. Much of the back wiring on the card container is printed. The summator lends itself very easily to any subsequent re-arrangement or additions to existing schemes, selector points having been provided for a variety of division ratios and scanning ratios. A further facility is the addition of sub-totals from two highways on to a totalising register, and finally outputs to printometers are also included.

The advantages of this type of summator over the earlier mechanical types are at once obvious. Its greater flexibility in general, and the relative ease with which parts can be manufactured and stocked, weigh heavily in its favour. The increased rate of impulsing now possible enables smaller units of power to be transmitted more often, making for better all round accuracy of final reading. The complete absence of ratchets in the stepping motors helps to keep wear down to a minimum. Furthermore, the transistors, used as they are in the switching mode, dissipate negligible power; a typical sixteen channel summator uses no more than 15 watts, of which more than half the power is dissipated in the motors. No ventilation is needed, thus keeping out the undermining effects of dust on the mechanism. The components used on the printed cards are Services approved and are considerably underrated. The cards and their respective socket locations are colour coded to assist insertion. Servicing, should the occasion arise, becomes no greater burden than replacing the offending card or motor, a terminal socket being provided on the latter to facilitate removal.

Materials for use in Meter-type Bearings

Two reports by G. F. Shotter, M.I.E.E., have just been released by the Electrical Research Association.

Results of Some Miscellaneous Investigations on Various Combinations of Materials for use in Meter-type Bearings. This report deals with a number of miscellaneous experiments, including tests on tantalum, molybdenum and zirconium pivots on sapphire cups, as well as the results to date of tests on three steel/spinel lubricated units run at 17 grammes.

Included are the results to date of a test on a tungsten/diamond unit run at 17 grammes dry and the final results of a test on a tungsten/diamond flat jewel lubricated with M.O.2 at 30 grammes: this test was started to enable the form of debris to be determined by means of X-rays. Finally, Dr. Tagg's calculations on the physical constants of tantalum, tungsten, molybdenum and zirconium are given.

Further Investigations on Materials for use in Meter-type Bearings. This supplement extends the results for steel/spinel lubricated units to a life of 400 × 10^6 revolutions. It also deals with previous tests on osmium-rhodium as a pivot material and gives results to date of further tests on four units using this alloy Finally, future tests on osmium-rhodium/sapphire units are discussed.

Practical Training in Production Engineering

THE Institution of Production Engineers have produced a booklet on apprentice training.

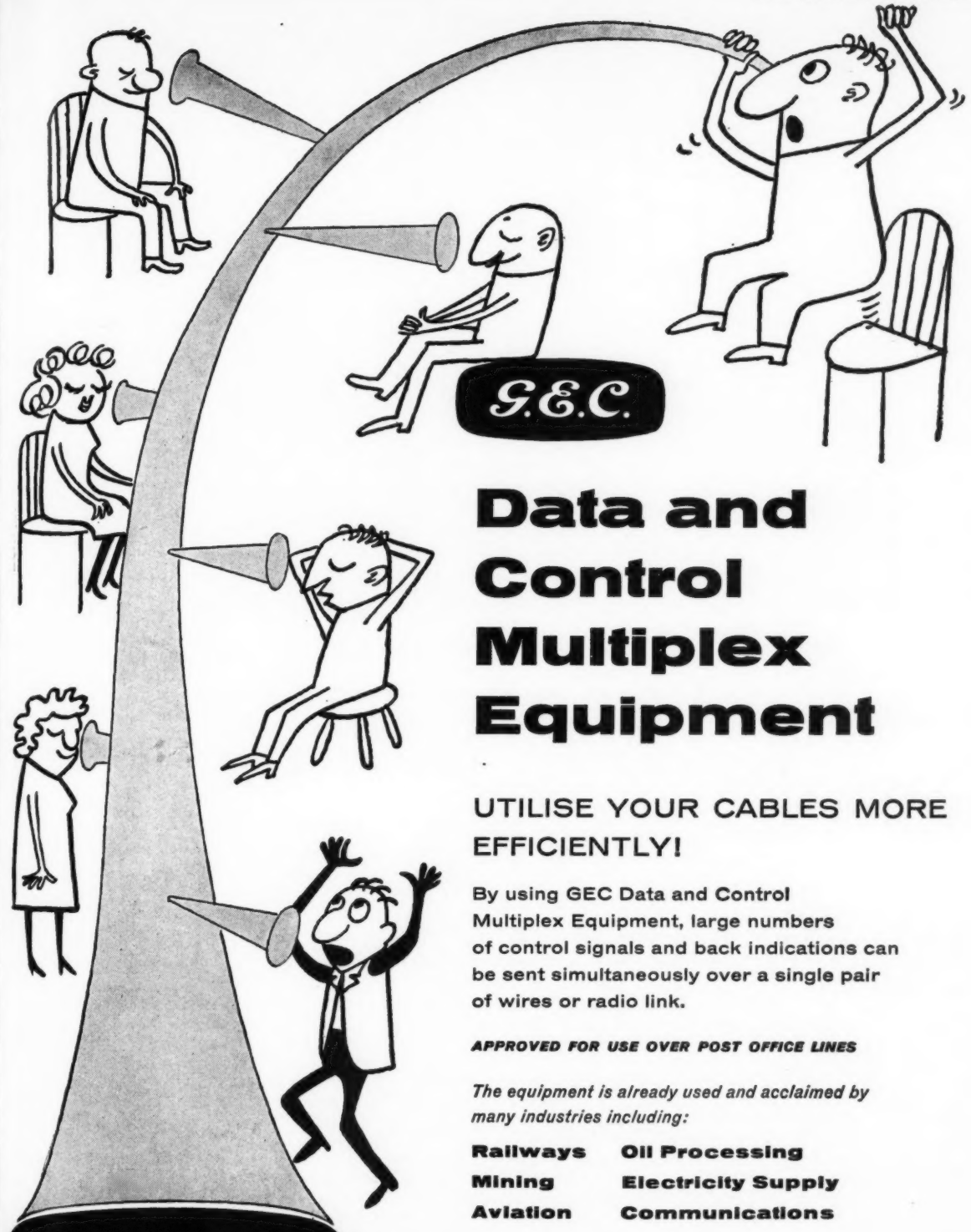
Adequate and appropriate practical training is one of the three essential requirements for membership of The Institution of Production Engineers. Although much has been done, and is being done, the greater interest now being shown in practical training, stimulated among other things by sandwich courses, has indicated that the time is opportune for restating the basic principles essential for such training.

No attempt has been made to produce sample courses or exercises, as it is believed that the principles stated, and elaborated in the Appendix, allow for the many differences in industry, product, organisation and type of production.

The Institution hopes that, with the co-operation of Industrial Training Officers, the heads of smaller firms and the organisers of Group Apprentice Training Schemes, it may eventually be possible to have training schemes approved as fully meeting the Institution's needs in much the same way that certain academic qualifications carry exemption from the Institution's membership examination.

Copies of the booklet, free of charge, may be obtained from the Headquarters of the Institution at 10 Chesterfield Street, London, Mayfair, W.1.

Circle **364** for further information



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SURVEY OF NEW INSTRUMENTS

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Diffusion Furnaces for Transistor Production

NEW high temperature diffusion furnaces designed to meet exacting temperature requirements have been installed in the Transistor Division of Standard Telephones & Cables Ltd. The furnaces were supplied by Royce Electric Furnaces Ltd. and are used in the production of high frequency, double diffused silicon transistors.

The furnaces are self-contained units incorporating a floor standing cabinet which houses all the electrical gear including control instruments, switchgear and transformers. They are suitable for use with nitrogen, oxygen and hydrogen atmospheres and are designed to take work tubes of either impervious fused alumina or transparent silica having an inner diameter of 2 inches.

Each furnace has both a preheat and a high temperature section, the preheat section being mounted on wheels so that it can be moved to and from the main chamber and locked in the required position.

The preheat section has a heated length of 12 inches arranged in three zones and providing a range of temperatures from 200 to 1,000°C. It comprises a high grade refractory tube housed in a refractory lined chamber and carrying three separate heater windings of heavy gauge, nickel chromium wire. The heater currents are supplied through three variable transformers.

The high temperature section has a refractory tube in a brick-lined chamber of high temperature refractory backed by thermal insulation. The heater length of 15 inches is controlled in one zone and provides any temperature required between 950 and 1,300°C. Heating elements are of silicon carbide and are positioned vertically along the side walls of the chamber. Supply to the heaters is taken from a single phase transformer having four primary tappings and a secondary winding with six coarse and six fine tappings.

The temperatures of the two sections are independently controlled and, within the specified temperature ranges, any desired temperature can be maintained in either section irrespective of the operating temperature of the other section. Automatic temperature control is by indicating controllers, two instruments controlling the preheat section and a third, an anticipatory controller, operating the high temperature section.

A feature of the furnaces is the provision of even temperature zones, one 2 inches long in the preheat section, the other 3 inches long in the high temperature section. In these zones any specified temperature within their respective ranges can be maintained with a uniformity and a stability with time of 2°C. The furnaces are so designed that a fall in temperature cannot occur between these two zones.

The Royce diffusion furnaces are each rated at 7¼ kW. They are 6 ft long by 2 ft 6 in. wide and have a working height of approximately 4 ft.

Circle **1** *for further details.*

Heavy-duty Transistorised D.C. Power Supply

A RECENT addition to the Gossen range of Constanter power supplies has now been introduced into the United Kingdom by Aveley Electric Ltd.

The unit is a heavy-duty, fully transistorised high stability d.c. voltage source for operation from a 40 to 60 cycle a.c. input supply. It has a voltage range from 5 volts d.c. (12 amp) up to 66 volts d.c. (5·4 amp) continuously variable. Warm up time from no-load to full-load is 0·2 milliseconds and ripple voltage is 1 millivolt.

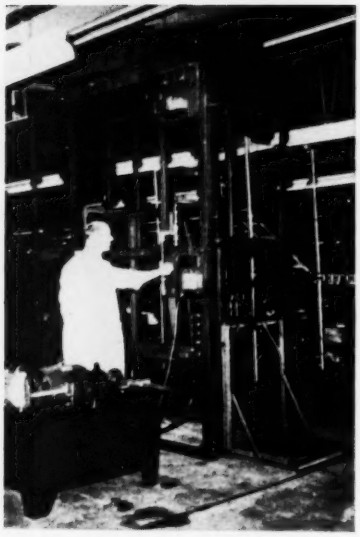
The instrument has good stabilisation characteristics and incorporates an electronically controlled automatic circuit breaker and thermal overload protection. Maximum ambient temperature at full load is + 30°C.

The Constanter is available as a rack-mounted or bench-type instrument.

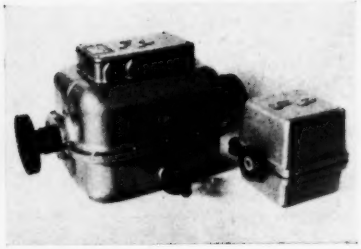
Circle **2** *for further details.*

Automatic Loading and Dipping for Batch Process Finishing Lines

THERE are many instances in industry where a heterogeneous batch of components must be passed through the finishing sequence prior to spray painting. The semi-automatic loader being marketed through R. & D. Industrial Services Ltd., consists essentially of a loading platform of which the model shown will take a load up to about 7 cwt. This is raised and the load passed to a centre platform which is above the level of the dipping tank. The operator from a control panel then causes the load to descend into the process tank such that it remains there for a period which can be pre-set, after



Automatic loading and dipping plant



Low conductivity electromag-netic flow-meters

Allen M.80 illuminated magnifier

which it is withdrawn and proceeds to the unloading platform on the other side of the equipment.

The model shown operates on a hydraulic principle but can also be operated mechanically where hydraulic services are not normally available. Where there are a number of tanks in sequence the batch of work can be placed on the loading platform and transferred to the centre platform for immersion in the first tank in the normal way. After a pre-set time interval it is raised and transferred by rails or rollers to the next tank where a similar elevating platform takes it to the next processing stage.

The advantages are that a mixed batch of components can be treated as well as, say, a single casting up to the load limit of the machine.

Circle **3** *for further details.*

Low Conductivity Electro-magnetic Flowmeter

FISCHER & PORTER have now developed a low conductivity electro-magnetic flowmeter system which considerably extends the range of applications on which this type of flowmeter may be used. Hitherto it has been impossible to use magnetic flowmeters for handling fluids with a conductivity of less than 20 micromhos/cm, but with the introduction of certain design changes Fischer & Porter have produced a magnetic flow-metering system which will handle liquids and slurries with a conductivity as low as 0·1 micromhos/cm. This means that the rate of flow of fluids not far removed from pure hydrocarbons can now be accurately determined by this magnetic meter.

The electro-magnetic flowmeter is obstructionless, accurate, simple, rugged, bi-directional and unaffected by changes in viscosity or density. These inherent advantages coupled with the increased sensitivity achieved by lowering the threshold of conductivity makes consideration of this instrument an important step in the planning of any new processing plant where flow is involved.

Circle **4** *for further details.*

Illuminated Hand Magnifier

THE illuminated 8× magnifier, ALLEN Type M.80, has a triple aplanatic lens which gives distortion free magnification. The object being viewed is brightly illuminated by a fully protected 2·5 volt lamp fitted under the lens.

The magnifier was designed primarily for the use of inspectors and supervisory staff in precision engineering works, including watch factories, textile mills and laboratories. It is small enough for the pocket, yet with a battery of adequate size for regular use.

The battery handle is made in brass, finished bright nickel and contains one standard No. 1839 battery.

The price is £6 15s. complete.

Circle **5** *for further details.*

Variphase Strobe Unit

In a vibration test installation, if a stroboscopic lamp is triggered at the same frequency as the drive to the vibration generator, the test piece always appears to be stationary. The presence of resonances and other features of the motion cannot be observed unless the stroboscopic lamp is triggered at a slightly different frequency to give a " slow-motion " effect to the vibration movement.

The Variphase strobe unit Type 1208 has been specifically designed to enable component or equipment on a vibration test to be viewed stroboscopically in " slow-motion " irrespective of the drive frequency within the range 5 c/s to 5 kc/s. The equipment can also be used to facilitate the optical calibration of vibration pick-ups or to provide a calibrated, continuously variable phase sine wave from a single phase sine wave input over the range 5 c/s to 5 kc/s.

The Dawe automatic l.f. sweep oscillator Type 444, a suitable power amplifier and vibration generator, together with the Variphase strobe unit Type 1208 and a Dawe stroboscope, provide the basic equipment needed for vibration resonance search and endurance

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tests as required in component and equipment specifications, including British Standards BS2011 and G100, Inter-Service Specifications RCS11, DEF-5011 and K114, and the International I.E.C. Publication No. 68.

Specification:

Input:	3–30 V r.m.s., 5 c/s to 5 kc/s sine wave
Phase-shifter output:	Sine wave at input frequency. Amplitude approximately twice the input level (maximum undistorted output 30 V r.m.s.) into 100 kΩ.
Stroboscope output:	Either positive pulses of at least 60 V or negative pulses of at least 120 V into 100 kΩ. Duration 0·1 to 2 milliseconds depending on output frequency. Maximum frequency determined by divider control.
Output difference frequency:	0 to 1·5 c/s
Output phase:	Continuously variable control calibrated 0–360°
Frequency divider:	Automatic operation giving maximum output frequencies of 100 c/s, 250 c/s, 500 c/s, 1 kc/s and 5 kc/s for any input frequency up to 5 kc/s.
Power supply:	200–250 V, 50 c/s, 60 W approx. 110 V, 60 c/s, model available to order.
Mounting:	Standard P.O. rack mounting, finish matt black. Detachable tilting bars for bench mounting available to order.
Dimensions:	19 × 8¾ × 8 in. deep (485 × 220 × 205 mm)
Weight:	20 lb (9 kg) approx.

Circle **6** *for further details.*

Proportioning Control Equipment

DEWHURST & PARTNER LTD. have developed an electronic grading operator (EGO) proportioning control equipment. This equipment is designed for the control of rapid and accurate mixing of many types of materials, e.g., aggregate, food and other materials.

EGO operates on basic units of volume of the final mix and any agglomeration of up to ten or more constituents may be obtained with a very high degree of accuracy.

Prerequisites for the operation of EGO are:

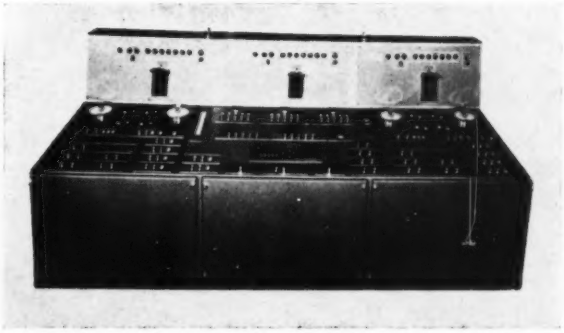
(i) storage of the mix components in fixed containers, e.g., bins or hoppers, each with electrically controlled gravity discharge;

(ii) a conveyor system linking all the containers.

By the operation of a single push-button, the predetermined mix is obtained on the conveyor and can be directed to the required discharge point.

EGO consists of a number of electronic units which may be housed as an entity or incorporated in an overall console or panel controlling ancillary features as well as proportioning control. These units include the unit generator which generates electrical pulses at unit delivery intervals. These pulses are transferred to a time scale known as the unit distributor which records and displays on the control panel the number of pulses generated from the commencement of the discharge cycle. Each container discharge device is contactor operated via a sensitive relay unit called a relay operator unit. Each such unit can be plugged into the timing cycle at any desired point according to mix requirements via a programme selector unit. This forms the heart of the equipment. Any required programme (mixture) can be set up on a programme tablet which consists of a Paxolin board measuring 7 × 4 × ⅜ in. with terminal plugs inserted at suitable spacings covering the discharge control of all the containers and delivery instructions. Positioning of the terminal plugs determines the programme. When this tablet is inserted into the programme selector unit the appropriate contacts are made and the desired programme is ready to be initiated.

Circle **7** *for further details.*



3 *EGO units mounted above a typical control console with motor control and ancillary equipment*

Bridge Motor Controller

AN adjustable speed drive which can provide a wide range of alternative ratings and control characteristics has been developed by Lancashire Dynamo Electronic Products Ltd.

This Series BMC.1 drive is supplied complete with motor and remote mounting control station for fingertip speed adjustment. In ratings from 1 to 3½ hp having a speed control range of 10 : 1, the equipment ensures good regulation of motor speed in the presence of fluctuating loads.

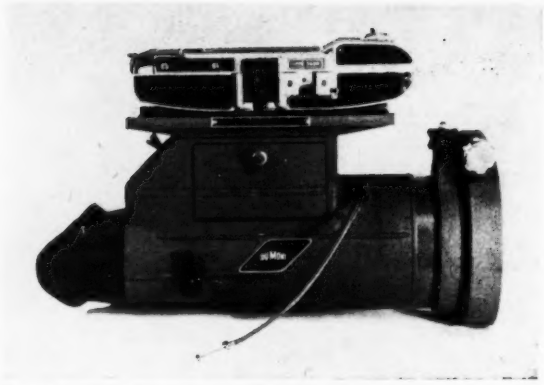
Optional features include reversing and dynamic braking, and on all models full protection against overload of the motor and control equipment is ensured by built-in current limit protection.

The equipment is contained in a substantial fabricated case and is intended for wall mounting. Motors are available having various enclosures and a wide range of base speeds and can also be supplied complete with gearheads where required.

Circle **8** *for further details.*

Oscilloscope Cameras

AVELEY ELECTRIC LTD. are marketing two cameras manufactured by Allen B. Du Mont Laboratories.



Du Mont oscilloscope camera, Type 302

The Type 299, with a variety of backs available for use with 120 roll or cut film, is for general purpose recording from 5 in. oscilloscopes.

Type 302 incorporates Polaroid—Land back for obtaining terminated " print a minute " records on transparent or opaque film. This Polaroid back can also be used on the Type 299 camera.

The cameras incorporate a specially designed sliding back on the housing which permits the operator to adjust the cameras in relation to the lens and expose more than one trace on the frame.

Detent stops position the camera backs for equally spaced exposures whilst the scale and pointer arrangement assists in positioning the back accurately for more than three exposures per frame.

Simultaneous screwing facilities for data recording are also provided.

The choice of lens available is the Woollensac Du Mont 75 mm *f*/2·8 three element lens, or a 75 mm *f*/1·9 six element lens.

Two bezel adaptors enable these cameras to be used with almost all 5 in. tube oscilloscopes.

Delivery for these cameras is 4 weeks.

Circle **9** *for further details.*

Flame Controllers

ETHER LTD. have developed a new range of flame controllers for safely igniting and monitoring multi-burner installations in industrial concerns.

They are fully transistorised, with plug-in circuitry and a.c. coupled amplifier, for use with gas-fired and oil-fired burners or burners working on a combination of both fuels. Moreover, they discriminate between flame and flame-radiation and are unaffected by the latter.

Series 704 flame controllers can be supplied for controlling up to 6 flames at once, depending on customers' needs. Each flame is controlled by a " flame-eye ", comprising a lead-sulphide cell, and a transistor amplifier which is sensitive to the modulated component in the flame-radiation. The presence of the flame is indicated by an output signal from the transistor amplifier which, in turn, switches a silicon transistor.

The circuitry of all Series 704 flame controllers is so arranged that the pilot relay, which interlocks with the flame relay and safe-start relay, cannot be energised until all the transistors are switched to " flame-on " positions. Absence of one or more flames will de-energise the pilot relay and indicate an alarm condition.

When switched on, the internal main connection is delayed for a pre-purge period that can be varied between 30 and 120 seconds. After the delay an ignition light switches on. Then a push-button is pressed which causes a solenoid valve in the pilot-burner line to open. Simultaneously, the ignition transformers produce sparks at the pilot-burner tips which ignite the pilot-burners. The " flame-eyes " then see the flames and immediately register the " flame-on " position, whereupon the main solenoid valve is energised to open the main fuel supply.

If the burners are controlled by a modulating valve, the interlocking contacts (which until now have held the valve in the " low-fire " position) operate and allow the burners to go on control.

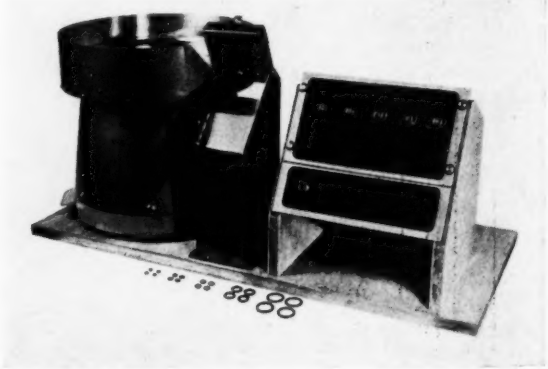
If flame-failure occurs, the pilot valve and main valve close, the control valve closes to " low-fire " position, and the alarm signal is given.

Circle **10** *for further details.*

Dekatron Batch Counters

COMPACT batch counters, with 2, 3, 4 or 5 dekatron tubes, which can be supplied with many modifications to suit particular applications, are the latest developments in the Pentechnique Ltd. range of counting units. Capable of batching numbers up to 99,999 at rates up to 5,000 per second, the units can be fed from photo-electric or magnetic pick-ups. The lower section of the units can have controls and circuitry specifically designed for the type of feed equipment to be used and the batch output signal can be in the form of relay contact closure or electrical signal.

The illustration shows a 5-dekatron batch counter used with a vibratory bowl feeder and photo-electric pick-up to count pre-selected quantities of rubber "O" rings. Two simple adjustments cater for 15 different sizes from $\frac{7}{32}$ in. o.d. to $\frac{5}{16}$ in. o.d. All controls, including those for the bowl feeder, are grouped on the lower panel of the batch counter and special circuitry ensures foolproof operation. The " Start " button resets the



Dekatron batch counter

dekatrons to zero to initiate the process and if, for any reason, the resetting is faulty the bowl feeder will not be energised. The operator is thus relieved from the necessity to check that the resetting is correct. If, during a count, it is required to stop the bowl feeder the " Stop " button can be pressed—subsequent operation of the " Start " button will not reset the dekatrons but will allow the count to continue from where it left off.

A variety of magnetic and photo-electric pick-ups can be supplied to detect a wide range of components. Mounting arrangements for the pick-ups and adaptations of bowl feeders can be undertaken if required.

Basic prices for the batch counters range from £65 to £125, depending upon the number of dekatron stages and the control circuitry needed.

Circle **11** *for further details.*

Mark Counter

THE Hellermann mark counter is constructed in chrome-finished steel. A simple depression of the felt tip against the bin or stock item to be checked, and the mark counter records the number counted and clearly marks with ink. This means accurate recording and identification in one operation.

Each mark counter is guaranteed and weighs only 7 oz and is supplied in a strong plastic case complete with 5 different coloured pens which have an ample supply of ink. New pens can be replaced within seconds.

Circle **12** *for further details.*

Dual-purpose Solenoid Valve

THE Skinner series of V.10 solenoid valves has recently been augmented to include a dual purpose valve, 3-way, normally open or normally closed, as circuit conditions may dictate.

Known as the V.18 Model, it is suitable for hydraulic pressures up to 1,000 p.s.i.

The standard range of valves, Models V.11, V.12, V.13 and V.15 are now suitable for hydraulic pressures up to 2,000 p.s.i. and in some cases 3,000 p.s.i.

These valves are of compact design with stainless steel body and internals. They have an equivalent orifice to $\frac{3}{32}$ in. diameter and are available with explosion-proof housing.

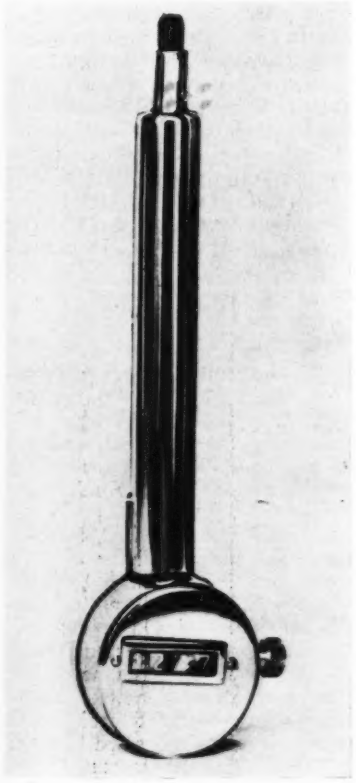
Coil consumption is 10 watts for alternating current supply.

Circle **13** *for further details.*

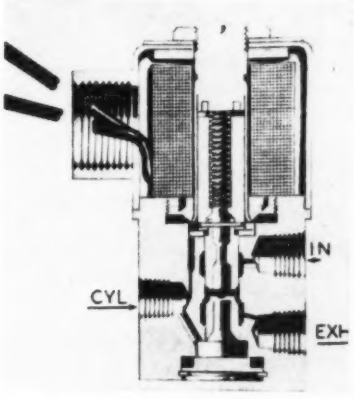
Portable Oxygen Analyser

SERVOMEX CONTROLS LTD. have now developed a portable industrial oxygen analyser instrument utilising a magnetic susceptibility measuring cell.

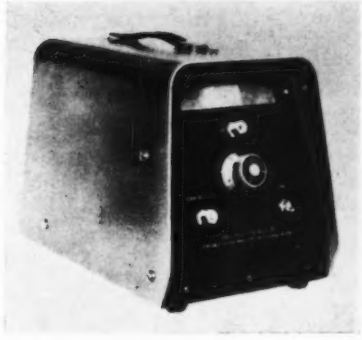
The Type DCL 101 portable analyser is a battery-operated device which can be regarded as an alternative to the Orsat apparatus for determination of oxygen anywhere in the range 0–100% to an accuracy of ±0·1%. Operation is simple and, as the device is linear, calibration at two points is sufficient to standardise over the whole scale. The zero is highly stable and a



Mark counter



Dual-purpose solenoid valve (de-energised)



Portable oxygen analyser

check of the span using air as a test gas is sufficient for most normal uses.

The analyser may be used with static samples or with a continuously flowing sample at rates up to 150 ml/minute. The sample must be filtered and cooled sufficiently to remove condensate, but there are otherwise few restrictions. The measuring cell is particularly tolerant of variation of sample components other than oxygen and it is not in any way affected by thermal conductivity or density variations.

Experience with the industrial analyser has shown that the DCL measuring cell is extremely robust. It contains a very light dumb-bell shaped test body suspended by a platinum ribbon in a non-uniform magnetic field. The torque on the test body produced by the presence of oxygen in the measuring cell is balanced by passing current through a coil wound on the dumb-bell. The balance condition is observed by means of a light spot reflected on to a scale and is obtained by adjusting a calibrated source potentiometer. The read-out is taken direct from a linearly calibrated ten-turn dial.

It is 13 inches in length, $8\frac{1}{4}$ inches in width and $9\frac{1}{2}$ inches high and weighs only 18 pounds.

Circle **14** *for further details.*

Dry Reed Relays

B. & R. RELAYS are now in production with two dry reed relays. One of the great advantages of dry reed constructions is the very high life expectancy (20×10^6 operations at maximum contact rating). The contact resistance is only 0·030 ohms. The new relays are of plug-in type. Type RO1 is mounted on an 8-pin base, and will hold up to three reeds. Type RO2, which apart from the base is the same size, has a 14-pin base, and has been designed to hold 4, 5 or 6 reeds. Both relays are d.c. operated, and measure $1\frac{3}{8}$ in. in diameter, being about $3\frac{1}{4}$ in. high. The nominal operating power for one reed is 0·1 watts, 0·9 watts for six reeds. Both relays are already being successfully used in a number of industrial applications, in conjunction with counting and photo-electric control systems.

Circle **15** *for further details.*

Electro-magnetic Counter

COUNTING INSTRUMENTS LTD. Series 400 electromagnetic counters are available with four figures and either mechanical or electric reset.

They are designed to meet the growing requirements for banks of counters, being compact but having the added advantage of large wheels $\frac{3}{4}$ in. (19 mm) diameter with figures $\frac{7}{32}$ in. (5·4 mm) high.

The figures are white and sunk into the figure band for greater readability.

The construction ensures long life, actual tests showing that between two hundred and three hundred million counts can be expected at a counting rate of 25 counts per second.

The counter is built into a Mazak diecast case. The dimensions are $2\frac{3}{4}$ in. wide by $2\frac{3}{16}$ in. high by $2\frac{5}{8}$ in. long.

The Series 400 electric counter is priced at present at £7 for the d.c. version and £7.15s. for the a.c. model.

Circle **16** *for further details.*

Direct Line Instrumentation System for Remote Control

THIS system comprises a pressure operated transducer unit which feeds a signal to a repeater indicating instrument or instruments which can be located at several points in an installation.

The transducer unit can be supplied as either a diaphragm gauge for extremely low pressures or as a Bourdon tube operated unit for medium and high pressures.

The pressure-sensitive element actuates a differential transformer, comprising a magnetic core moving in a coil having a primary winding and two secondaries. When the core is in the central position the output from these secondary windings is balanced in phase opposition and so cancelled. Any movement of the core disturbs the voltage balance of the secondaries and produces a differential output.

This principle of the true position transmitter requires negligible energy to convert position into force, and will operate without adjustment for a considerable time.

The differential transformer is constructed to produce good linearity and the core diameter is kept small to eliminate counter force effects. Since the transformer windings are outside the pressure system, there is a complete elimination of moving spindles and electrical connections passing through pressure seals.

The $2\frac{1}{2}$ in. diameter repeater indicating instrument is flush mounting with a concentric scale. (Approximately 4 in. linear length of scale.)

The housing also contains the transformer and constant voltage control unit. Provision is made on both instruments for compensation for lead resistance.

The electrical system is fed from a.c. mains supply, 230 volts, single phase, and is transformed to a convenient constant controlled voltage to suit the differential transformer primary winding. The signal current is rectified d.c. for transmission to the repeater indicating instrument, the rectifying unit being fully transistorised.

At an extra cost the transducer unit can be fitted with a 4 in. direct reading instrument at the pressure source.

Circle **17** *for further details.*

Photomultiplier Tube

RCA's new Type 7850 photomultiplier tube is a 12-shape version of the 10-shape Type 7746. It is designed for fast coincidence work and other low light level applications where wide bandwidth, small spread in electron transit time and good resolution are desired. It is suited to detect events that produce only a few photons.

When operated at a supply voltage of 2,300 volts, the 7850 has median luminous sensitivity of 6,000 amperes/lumen; current amplification of 86,000,000; and anode pulse rise time of 2×10^{-9} second. Median pulse height resolution for the 7850 is 8·5%.

Design features include a semi-transparent photocathode on the inner surface of the spherical faceplate of the tube, a minimum photocathode diameter of 1·68 inches, and a focusing electrode with external connection. This 12-stage type employs the recently developed enclosed focused in-line dynode structure.

The spectral response of the 7850 covers the range from about 3,000 to 6,500 Å. Maximum response occurs in the blue region at approximately 4,400 Å.

Circle **18** *for further details.*

Electrolube Aerosol Dispenser

A NEW aerosol dispenser for Electrolube (No. 2A) is now available at the price of 22/– net trade.

This 6 oz aerosol applicator combines the actions of Electrolube No. 1 and No. 2 in loosening tarnish, lubricating and spark inhibiting. A five inch " snorkel " extension is also provided for directing the spray into inaccessible places.

Circle **19** *for further details.*

Industrial Television Recorder

A TELEVISION tape recorder VR-8000, designed exclusively for non-broadcast closed-circuit applications in educational, industrial and governmental fields, has been developed by the Ampex Corporation and will be available through Ampex Great Britain Ltd.

The new Ampex television recorder employs a single video record/reproduce helical-scan head in contrast to the broadcast television recorder which utilises four transverse-scan recording heads mounted on a revolving drum. It operates at a slower tape speed, and occupies less floor space.

The new recorder has been designed to be operated by personnel with minimum technical training. It has few operating controls and minimal maintenance in normal operation. Tapes recorded on the new Ampex VR-8000 can have as many as three different sound tracks in addition to the recorded television picture. Tapes recorded on any VR-8000 can be played back on any other VR-8000.

Circle **20** *for further details.*

Photographic Automation

THE ROBOT 35 mm camera equipment, manufactured by Robot-Foto GmbH, Dusseldorf, is now available in this country through Telford Products Ltd.

The Robot equipment is built around the camera itself. Two models of 35 mm spring-driven cameras are available, each in several types. The two models are known as the Royal, which is suitable for personal and industrial use, and the Recorder, intended solely for industrial use; the latter has no viewfinder or range-finder, and is therefore exempt from purchase tax.

The Royal is available in three frame sizes, 24 × 36 mm, 24 × 24 mm, and 18 × 24 mm. The Recorder is available with four frame sizes, 24 × 36 mm, 24 × 24 mm, 18 × 24 mm, and also 6 × 24 mm, the last especially valuable in photographing, say, a row of dials with maximum film economy.

The cameras incorporate automatic operation by means of a spring motor, and are capable of making 18 exposures. Pressure on the release button not only makes the exposure, but automatically moves the film, cocks the shutter, and counts the exposure. Photography at the rate of up to six exposures per second, a type of photography intermediate between still and ciné work can be achieved.

The normal cassette or spool carries 5½ ft of film. When it is required to expose this length without re-winding, a booster motor—clockwork or electric—may be simply attached to the camera, automatically winding the built-in motor after each exposure. The electric motor runs on 24 V a.c. Other driving mechanisms are also available.

The camera may be provided with an electromagnetic release for remote control operation. The booster motor may form part of an automatic recording system, capable of making exposures at any desired rate. The electrical control takes the form of two units, the electric timer and the mains unit; the former is simply set to the time interval required, and the camera will continue operating until the film is exhausted. An electronic timer provides a range of ¼ to 60 seconds, and the electro-mechanical timer from one minute to 24 hours.

The accuracy of timing of exposures means that any number of cameras can be fixed simultaneously with perfect synchronism. The same feature has proved itself invaluable in photographing cathode ray images, including radar; the " reverse " remote release makes it possible to keep the shutter open until the required trace is recorded, then close it and advance the film.

Circle **21** *for further details.*

20-Ampere Silicon Rectifiers

RCA announces 14 new improved 20-ampere silicon rectifiers in the JEDEC DO-5 package designed to meet stringent environmental requirements of military and industrial power supplies. Reverse-polarity versions of these rectifiers are also available—1N248-RC, 1N249-RC, 1N250-RC, 1N1195-RA, 1N1196-RA, 1N1197-RA, 1N1198-RA.

These new industrial rectifiers directly replace all corresponding prototypes and are designed to assure superior performance in critical power-supply applications.

These new rectifiers incorporate:
peak surge-current rating at 350 amperes
p.i.v. ratings from 55 to 600 volts
extra-high-strength copper-alloy mounting stud, withstanding installation torque of 75 inch pounds
high output current:
up to 84 amperes— 6 rectifiers in 3 phase full-wave bridge circuit
up to 60 amperes— 4 rectifiers in single-phase full-wave bridge circuit.

Circle **22** *for further details.*

Silicon Rectifiers

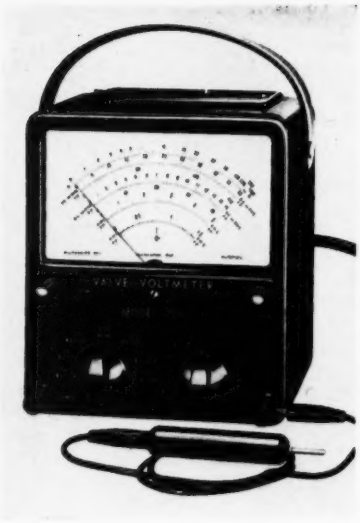
RCA announces four new silicon diffused-junction rectifiers in a tubular, metal case with axial leads in the same small case used in the standard JEDEC TO-1 transistor package.

This 0·405 inch long and 0·240 inch diameter flangeless case features a single glass-to-metal hermetic seal and fits easily into standard assembly and mounting procedures.

There is no derating for operating at ambient temperatures up to 75°C.

The p.i.v. ratings are from 200 to 800 volts, with forward currents up to 750 mA.

Circle **23** *for further details.*



◀ *Portable valve voltmeter*

▲ *Miniature precision integrating gyro*

Colour transparency copying instrument

Valve Voltmeter

THE portable valve voltmeter, Model 172A, produced by Taylor Electrical Instruments Ltd., is completely stable after only a short initial warming up period, and is not affected by mains fluctuations or long periods of continual use.

It has a high input impedance of 11 MΩ on all d.c. volt ranges, and 830 kΩ to 1·5 MΩ on a.c. volt ranges. This negligible loading on the circuit under test results in a much higher accuracy of measurement and enables the instrument to be used in circuits where a normal multirange instrument would be inadequate.

The Model 172A can be used at frequencies of over 200 Mc/s in conjunction with a small crystal probe.

The instrument is portable. It weighs 5½ lb and the outside measurements of the case are: 7½ × 6¼ × 4½ in.

Only two " permanent " connections are necessary to the terminals of the instrument as the selection of ranges is simplified by the use of a range selector switch, thus obviating the inconvenience of re-connecting leads.

The instrument is designed to operate from a.c. mains voltage between 110 and 240 volts at 40 to 50 c/s. The primary of the mains transformer is fused to protect this component from damage, in the event of excessive overload or shorts. The mains adjustment panel and fuse holder are readily accessible by the removal of a special covering plate.

Circle **24** *for further details.*

Miniature Integrating Gyro

INTRODUCED recently by the Norden Division of United Aircraft Corp., and now available in the U.K. through Ketay Ltd., is a new miniature integrating gyro, Type RI-203.

Applications for this precision gyro include inertial navigation and guidance for missiles and aircraft, stabilisation of shipboard devices and many others demanding precise dynamic angular measurement. The gyro is used, in conjunction with Norden single axis accelerometers, in the new miniature all-altitude inertial platform which was recently shown in the U.K.

Features of the new gyro include low drift rate of less than 0·02 deg/hour; excellent day-to-day stability of 0·10 deg/hour without trimming and the unusually long life of 3,000 hours. The low drift has been achieved with a spin motor turning at only 12,000 rev/min, a speed which contributes substantially to the unit's long life.

Only 3·1 in. long by 2 in. in diameter, this guidance gyro, including heater and shields, weighs one pound.

Circle **25** *for further details.*

Colour Reproducer

Now available from Photo-Science Ltd. is a transparency copying instrument known as the Heiland Repronar. It utilises an electronic-flash light source and is capable of performing more than 20 different colour reproduction processes, including: duplicating, cropping or enlarging of colour slides; enlarging 16 mm movie frames to 35 mm; reducing 2¼ inch slides to 35 mm; correcting of underexposure, overexposure, colour balance or distortion; framing with masks; experimenting with vignettes; creating montages; adding textures and screens; creating sandwich effects; producing or duplicating filmstrips, and producing black-and-white negatives from colour slides or colour negatives from colour slides.

The Repronar system (list price: £205) includes a specially designed 35 mm single-lens reflex camera with specially designed *f*/3·5 lens; an easel with slide and filter holders; an incandescent light source for transparency viewing and focusing, and a Strobonar electronic flash unit for actual exposing.

The Repronar dimensions are: 20⅝ in. high, 9⅛ in. wide and 11¼ in. deep. It is manufactured in the U.S.A. by the Heiland Division of the Honeywell organisation and is being imported into this country by Honeywell Controls Ltd. All sales and service functions, however, will be handled by Photo-Science Ltd., who have been appointed sole sales agents.

Circle **26** *for further details.*

Silicon Power Transistors

RCA announces the addition of two new 40-watt n-p-n silicon mesa transistors to its broad industrial line. These new units, the **2N1768** and **2N1769**, utilise an hermetically sealed package having an offset pedestal-and-stud mounting arrangement for positive heat-sink contact.

These new RCA transistors are designed for such applications as d.c.-to-d.c. converters, inverters, choppers, voltage and current regulators, d.c. and servo amplifiers, and relay-actuating circuits.

They have a low saturation resistance of 1 ohm and are capable of operating at temperatures up to 200°C.

Circle **27** *for further details.*

High-Mu Triode

RCA have added the **7895**, a high-mu triode for industrial applications, to its range of nuvistor tubes. This new tube has an amplification factor of **64** and is intended for a wide variety of applications in industrial equipment. It is capable of providing high gain with low noise in a wide variety of amplifier applications including: cascade circuits, r.f. and i.f. stages, " on-off " control circuits, and resistance-coupled amplifier circuits; excellent stability as an oscillator from very low audio frequencies up into the u.h.f. region; and reliable performance in applications such as " on-off " control where long periods of standby operation are required.

It has low heater drain (**6·3** volts/**135** milliamperes), high transconductance at low plate current and voltage (9,400 micromhos at **7·0** milliamperes and **110** volts), and small power requirements (plate and heater input—each less than one watt).

Circle **28** *for further details.*

Pressure Switch

THE miniature pressure switch Type PS/MIN has been developed by Londex Ltd. as an addition to their range of pressure switches described in list 119/J, and is primarily intended for applications where the space available is restricted. Although primarily intended for applications where the pressure at which the contacts operate is pre-set, internal adjustment can be made between the limits of the three adjustable ranges quoted below. The pressure switch is pre-wired and, as standard, supplied complete with 4 ft of 3-core cable. The switches are designed for use with non-corrosive liquids and gases up to a maximum temperature of 100°C. The net weight of the pressure switch is 5 oz.

The PS/MIN has a machined brass body which is nickel plated, incorporating a hydraulically formed seamless phosphor bronze bellows as the pressure-sensitive element. Snap action contacts and adjusting screw are housed under a light grey hammer finish aluminium cover.

Pressure Entry: $\frac{1}{8}$ in. or $\frac{1}{4}$ in. male B.S.P. thread

Contact Rating: Single-pole changeover (s.p.d.t.) snap action silver contacts rated up to:

5 amp resistive at max. 250 V a.c.
2 amp inductive at max. 250 V a.c.
2 amp resistive at max. 30 V d.c.
1·5 amp inductive at max. 30 V d.c.

A special double-pole changeover version, Type PS/MIN/DP, is also available and information on this type can be supplied on receipt of details of requirements.

The " contact reset differential " listed below is the difference between the pressure at which the contacts operate and reset. This differential is non-adjustable and increases slightly when the operating pressure is increased, i.e., a PS/MIN.2 pre-set to operate its contacts on pressure rising to **15** p.s.i. will reset at approximately **12** p.s.i. (**3** p.s.i. contact reset differential). If the switch is set to operate on pressure rising to **80** p.s.i. the contacts will reset at approximately **75** p.s.i. (**5** p.s.i. contact reset differential).

Type No.	*Maximum Pressure* p.s.i.	*Adjustable Range* p.s.i.	*Reset Differential* p.s.i.
PS/MIN.1	200	10 to 30	Approx. $1\frac{1}{2}$–$2\frac{1}{2}$
PS/MIN.2	300	15 to 80	Approx. 3 –5
PS/MIN.3	350	55 to 180	Approx. 6 –14

Circle **29** *for further details*

Insulation Material

ROSITE LTD. now have available an addition to their range of insulation materials supplied as mouldings to the electrical industry known as Rosite **3250**.

The hot-moulding technique used in the production of Rosite **3250** gives improved dielectric and mechanical strength, greater dimensional accuracy, and increased resistance to moisture absorption. It makes possible the moulding of more complex and finer sections, and automatically gives a better surface finish without post treatment. In addition, the heat resistant qualities are superior to the characteristics normally found in polyester resin/glass products. All these advantages are achieved without losing any of the arc quenching, arc resistant and non-tracking qualities associated with other Rosite materials.

Dielectric strength (volts/thousandths of an inch) —300
Dielectric constant — 3·25
Flexural strength (p.s.i.) — 10,000 to 12,000
Impact strength (Izod) — 2 to 8 depending on glass fibre content
Compressive strength (lb/in²) — 20,000 to 25,000
Density (lb/in³) — 0·075
Specific gravity — 2·1
Flammability — Self extinguishing
Ignition time — $3\frac{1}{2}$ minutes
Arc resistance (ASTM seconds) — 180 to 240 depending on glass fibre content. (Will not track)
Water absorption (% 24 hour immersion) — 0·1

Variations in the glass fibre and other contents can be introduced at time of manufacture to meet specific requirements.

Circle **30** *for further details.*

End Quench Unit

THE end quench is a technique for assessing hardenability of steels, that is the depth and distribution of hardness induced by quenching. Moreover, by polishing and etching along the length of the bar, a whole range of microstructural effects may be assimilated in one specimen.

The technique may be applied with equal gain to non-ferrous alloys such as aluminium bronzes, also to those where a single phase precipitates. Another

application is in assessing the quench sensitivity of precipitation hardening alloys.

An end quench unit has been designed by Metallurgical Services Ltd. Interchangeable specimen holders are available for specimen diameters from $1\frac{1}{2}$ in. For these sizes the standard $\frac{1}{2}$ in. diameter jet is accepted as satisfactory, but the jet is changeable so that if it is desired to test specimens smaller than $\frac{1}{2}$ in. diameter, a smaller jet may be fitted.

The tank assembly, fabricated mainly by welding, is constructed from 20 gauge lead-coated steel. The $\frac{1}{2}$ in. diameter water jet (detachable) is mounted at the closed top of a tube rising from the base. The water pipe passes inside this tube so that it does not break through the wall of the tank. A drain pipe of adequate dimension is provided at the bottom of the tank.

The interchangeable specimen carriers are located by dowel pins and are secured by milled heads. The specimen holes in the carriers are arranged to give $\frac{1}{32}$ in. clearance, and the holes are countersunk on the underside so as to minimise contact with the specimens. The carriers maintain the quenched end of the specimen $\frac{1}{2}$ in. above the jet orifice.

Circle **31** *for further details.*

High-purity Mercury

FOLLOWING the installation of new equipment, Johnson, Matthey are now able to offer in quantity two grades of mercury for laboratory and industrial use.

Redistilled mercury has a maximum impurity content of five parts per million (mostly copper and silver), and triple-distilled mercury a maximum of one part per million. Every batch is examined spectrographically to ensure that the limits are not exceeded. The metal is supplied in 7, 14, or 28 lb containers, though other packings can be provided.

Circle **32** *for further details.*

A.F. Spectrograph

WITH the introduction of the Rohde & Schwarz audio frequency spectrograph Type FNA by Aveley Electric Ltd., audio frequency amplitude response and spectrum analysis can now be carried out faster and with greater accuracy.

The Type FNA resolves alternating voltages irrespective of waveform, making it possible to analyse pulse voltages (Fourier analysis), sound analysis, or analysis of complex movement (vibration, etc). Harmonic analysis and intermodulation measurements allow harmonic distortion, intermodulation distortion and modulation products to be determined. It is possible to investigate speedily, and in detail, the effect of component changes in circuits, particularly valve characteristics and non-linear devices.

An automatic frequency sweep allows all measured valves to be plotted by the built-in recorder, the charts of which provide convenient permanent records.

The Type FNA has a frequency range of 30 c/s to 20 kc/s, it has extreme selectivity which retains its absolute value over the entire frequency range and provides facilities for both linear and logarithmic indication.

Circle **33** *for further details.*

Recording Flue Dust Monitor

THE EEL recording flue dust monitor is designed to record automatically the emission of harmful dust, grit and oil particles from industrial boiler house chimneys and to give immediate warning to the engineer in charge of the offensive nature of the smoke plume before it leaves the main stack. Not only does this photo-electric apparatus prevent damage and offence to surrounding property, but it also gives warning of the inefficiency of solid fuel pulverisation, dust collecting plant, oil firing apparatus and the fuel in question.

The EEL recording flue dust monitor consists of a sampling and measuring head, a control unit and a recorder unit. The sampling and measuring head is fitted to a duct leading to the chimney and samples the percentage of coarse dust and grit photo-electrically (with progressive emphasis from 20 microns upwards), at predetermined intervals, usually of 15 minutes. If the dust burden reaches offensive proportions the signals passed to the control unit will automatically actuate an alarm system. Should the burden become so great as to be incapable of being recorded at normal set intervals, the instrument automatically records more frequently. The recorder unit provides pen readings graphically on a 24 hour chart. The chart presents these readings in units of percentage obscuration/minute relative to a vertical surface exposed to the dust.

The EEL recording flue dust monitor has been developed in conjunction with the Central Electricity Research Laboratories and has applications in electricity power stations, chemical and oil plants, brick and cement works and many other industries.

Circle **34** *for further details.*

Magnifier for Drawing, Drafting and Plotting

A NEW illuminated low power magnifier for use when working on maps, charts, detailed graphs and similar precision drafting and plotting work has been produced by P. W. Allen & Co.

The magnifier, the Allen M.209, gives a 2× linear magnification over 5 in. diameter circle with provision for using scales or rules under the lens and with ample room for the hand and pen or pencil. The whole area is brightly and evenly illuminated by a low voltage lamp giving a " white " light.

The magnifier resting on the job is always at the optimum viewing distance and can be used equally well on flat or medium sloping boards.

The body, 8 in. diameter by 6 in. high, is made in aluminium with rubber mouldings covering the open edges and is finished in silver grey hammer stove enamel.

Bright " white " light is provided by a 24 watt, 24 volt lamp. The low voltage supply is obtained from the mains through a transformer plug.

Models for export and for non-standard outlets are fitted with a rubber moulded socket for the transformer plug and 3 ft of 3-core cable to which a suitable plug can be attached.

The price (ex-works) is £10 15s. standard model.
£11 5s. export model.

Circle **35** *for further details.*

Cycle counter/current meter

A.C. microvoltmeter, Type TF1375

Cycle Counter/Current Meter

HIRST ELECTRONICS LTD. have added the cycle counter Type CC1 to their range of HED instrumentation. The same toroids can be used on the cycle counter as are used in the company's resistance welding current meter.

As no direct connections to the welding machine are necessary, many machines may be tested without being shut down in order to connect the cycle counter. Another advantage is that phase shift waveforms can be counted without any readjustment to the instrument.

Whilst this instrument has been primarily designed for resistance welding, it has many applications and the specially designed hook search coil Type SC/2 is for placing on ordinary types of cables; also, the signal input can be any a.c. supply from 6 to 400 V or by recording the closure of normally open contacts.

The standard model is a 2-stage dekatron reading 1 to 99 cycles. A further model is available for reading on a 3-stage dekatron 0 to 999 cycles. By counting the revolutions of the 10's in the case of the standard instrument and the 100's in the 3-stage model, timing in excess of 99 and 999 cycles can be obtained.

Circle **36** *for further details.*

A.C. Microvoltmeter

HIGH gain and freedom from hum characterise the new a.c. microvoltmeter, Type TF 1375, introduced by Marconi Instruments Ltd. Covering the range 5 μV to 15 volts in twelve ranges, it is fully transistored and completely portable, with self-contained battery supply. The frequency range is 50 c/s to 1 Mc/s with switch-selected l.f. rejection.

Basically, the instrument consists of a frequency-compensated input attenuator with decade steps, and a seven-transistor frequency-compensated amplifier having a voltage gain of approximately ×5,000. Output from this amplifier is rectified in a full-wave bridge circuit before application to the meter; in addition, the output from the penultimate stage is available at a front-panel outlet.

The 4-inch meter has an overload-protected movement with clear high-discrimination voltage and decibel scales.

The TF 1375 can be used for a variety of purposes; for example, as an oscilloscope pre-amplifier, as a sensitive measuring-bridge detector, or for field strength and aerial tests. In conjunction with a suitable pick-up loop, measurement may be readily made of leakage flux emanating from mains transformers and electric motors. Input impedance and sensitivity are such that it can be used as a microammeter for detecting currents as low as 10^{-10} ampere.

The price is £66.

Circle **37** *for further details.*

Carbon Resistors

A RANGE of close tolerance imported high stability carbon resistors is available from Mayra Electronics Ltd. Values are in decade multiples of 10 Ω, 20 Ω and 50 Ω up to 10 MΩ, and a tolerance of ±0·5% is claimed below 1 MΩ. Temperature coefficient is better than ±0·025%/°C up to 100 kΩ, rising to ±0·05%/°C at 1 MΩ.

Circle **38** *for further details.*

Analogue Computers for Technical Education

As part of the present drive towards more up-to-date methods in technical education, the Computer Division of Redifon Ltd. has introduced a new range of analogue computers specially designed for use in educational establishments.

Only after a great deal of discussion with technical colleges and university departments have Redifon decided to put their educational computers on the market. Their design provides for a wide range of engineering calculations, and considerable thought has been devoted to the layout of the controls to give ease of use and clarity of problem display on the programming board. This has been done while keeping the cost to a minimum and providing facilities for easy extension or modification of the equipment.

Such flexibility and low cost is made possible by assembling the computers from the RADIC (Redifon Analogue Digital Computing) system, which allows many different computing and data handling equipments to be built up from standardised electronic units. The basis of the educational computer design is a module of 10 operational amplifiers, which can be expanded to 20 amplifiers if necessary. Alternatively, the expansion can be made to 14 amplifiers, and the extra space used for other computing elements such as servo multipliers. All this can be done in the existing cabinet (measuring 43 in. wide by 33 in. high by 24 in. deep) and with the existing power supplies.

The amplifiers can be used with resistors for adding,

subtracting, sign changing etc. (six resistance inputs being provided for each amplifier), or with capacitors for integrating. Ten coefficient potentiometers of the helical type are mounted on the front door of the 10-amplifier module. Non-linear function units can be supplied to order.

Programming the computer is made simple and clear for the student by the method of laying out the patchboard so that it corresponds with conventional analogue computer functional diagrams. Graphical symbols of the various computing elements are, in fact, printed on the patchboard so that they indicate the sockets to which these elements are connected. With the 10-amplifier computer the patchboard is divided into ten sections, each of which has a printed rectangle, representing the amplifier, and printed symbols of resistors, capacitors and bus-bars between the appropriate sockets. Mathematical expressions such as transfer functions can be written in the amplifier rectangles by wax pencil. The actual programming, or " patching ", is done by interconnecting the sockets with links or flexible leads, and the whole layout is arranged to facilitate the feedback connections which are necessary for many analogue computer problems.

The timing system for the computer provides seven different sweep speeds and has a facility for holding the computation at any desired stage. Automatic resetting of the computing elements takes place instantaneously during the fly-back period of the external cathode-ray tube.

To cater for all possible requirements and financial situations Redifon are making the computers available in two different forms: as complete and tested machines, and as partly assembled kits. With these flexible arrangements a user can order equipment to suit his immediate requirements, then expand or adapt it at later stages when the need arises and when financial budgeting allows.

A mobile demonstration unit will shortly be on tour in Britain to visit all those educational establishments which have already shown interest and wish to see the computer in operation.

Prices for the educational computers range from £1,590 for the " basic " RADIC 10/20 model.

Circle **39** *for further details.*

Amplifiers

THREE new amplifiers for use in electronics, radio and communications are available from Honeywell Controls Ltd. The units have low noise, low drift and high common mode rejection.

D.C. Amplifier

First is the Accu Data III d.c. amplifier, a chopper-stabilised, all-transistor d.c. amplifier designed primarily for use with strain gauges and thermocouples. Features which are combined in the Accu Data III are:

10 V or 50 mA output from signals as low as 0·15 mV single-ended or 10 mV differential, frequency response from d.c. to 20 kilocycles, noise and drift less than 0·007% on typical gains, completely variable gain adjustment, gain stability better than 99·99% and linearity to 99·99%.

Uses will include data handling, oscillographic, computer and servo applications. The unit occupies only 5¼ in. panel height, and 7 units fit across in a 19 in. rack width.

The Accu Data III has a self-contained power supply requiring 10 W at 115 V, 50-400 cycles. A 230 model is also available. It has seven calibrated single-ended gain positions, three differential gain positions and a ten turn potentiometer for intermediate gains up to 3·4 gain setting. The zero set position disconnects the source and shorts the input for precise zero reference. The entire amplifier is isolated from the outer case in all single-ended or differential gain positions.

Accessories include a simple seven-amplifier mounting frame occupying 5¼ in. of panel height. No cooling fans or heat sinks are required for normal operation, nor is the mounting rack required for isolation. No case is required for bench top use of individual amplifiers.

Preamplifiers

The other two new Honeywell units are preamplifiers for use with direct-recording or self-balancing potentiometer recorders. They both have differential inputs, one with ranges from 20 μV to 2 mV, the other 100 μV to 100 mV.

The 2HLA-7 preamplifier is designed to accept d.c. inputs as low as 20 microvolts and give full scale deflection on a 12 inch strip chart recorder with a response speed of ¼ second. It has an isolated differential input, 20 c/s frequency response, low noise and drift, and gains as high as 100,000. This model is designed primarily for use with the Honeywell ElectroniK ¼ second pen speed strip chart recorder, although it can be used with other circular and strip chart potentiometers. A two-tap voltage divider provides two outputs of 10 mV and 50 mV for rated input, thus enabling the preamplifier to be used for a large number of different input and output ranges. Overall gain is controlled by selection of three plug-in range units. The Honeywell model 2HLA1-4a is a general-purpose differential input d.c. amplifier for laboratory or process use. It provides high voltage and power gain and very low noise for use in d.c. measuring or control systems requiring frequency response from d.c. up to 20 or 40 c/s.

Both units are built to high industrial standards for convenience of use and long term reliability. Their mechanical features include input and output connections at both front and rear, and they may be bench or panel mounted, or the case and front panel may be removed for integral mounting.

Circle **40** *for further details.*

Automatic Control for Lighting

PHOTOELECTRONICS (M.O.M.) LTD. have now produced a fully automatic control unit for all types of artificial lighting.

The new unit—Type LUA—consists of a control containing three separate pieces of equipment interconnected but capable of being operated separately if required. They are:

1. A photocell control unit with a variable set point to operate the lighting ON and OFF acccording to the level of daylight intensity
2. A time clock with adjustable settings to over-ride

the photocell unit when required, e.g., from midnight to 8.00 a.m.

3. A 3 phase 30 amp contactor capable of switching a lighting load up to 6,000 watts.

In addition a photocell unit is provided mounted in a 1 in. diameter waterproof cast aluminium housing and this can be fitted at any distance from the control unit. It is positioned so that it can observe changes in daylight intensity and it will then feed the control unit with this information and operate the lighting according to the requirements of each installation. The equipment is fitted with suitable safeguards to prevent too frequent operation due to clouds or similar short period conditions affecting lighting intensity.

To suit special site conditions the various controls can be supplied in different combinations and smaller or larger contactors are available for different lighting loads.

The price is £19 19s. 0d. per set complete, and delivery is 4 to 6 weeks.

Circle **41** *for further details.*

High Vacuum Variable Capacitors

THE English Electric Valve Co. Ltd. now have available high vacuum variable capacitors. Five units comprise the range, three with capacitances of 5-30, 8-50, 16-80 pF and two with capacitances of 5·5-206 pF. The peak r.f. voltage is 15 kV for the first three and 8 and 10 kV for the other two.

By using a high vacuum as the dielectric, the spacing of the capacitor plates is reduced to about one tenth of that required for an air dielectric unit of comparable rating, giving a capacitor of extremely compact design.

The construction follows in principle that of the well known high vacuum fixed capacitor wherein the capacity elements are made up from overlapping concentric cylinders. The variable capacitor, however, uses a metal bellows, which forms part of the vacuum envelope, to transmit an axial motion to one set of cylinders, thus enabling the overlap to be adjusted. The processing and assembly of the metal bellows play a major part in the successful manufacture of these capacitors. A linear capacity law is ensured by the nature of the construction except at minimum capacity when fringe effects cause a small deviation. The capacitors, the largest of which has dimensions of only 9·5 in. by 3·5 in., are designed to comply with the requirements of RCS11.

Circle **42** *for further details.*

Proscontroller

WITH the general acceptance of off-peak electric space heating by means of warmed floors and block type thermal storage heat, the need for proportioning temperature controllers to adjust automatically the charging times of the installations in accordance with the prevailing outside weather conditions has become increasingly apparent.

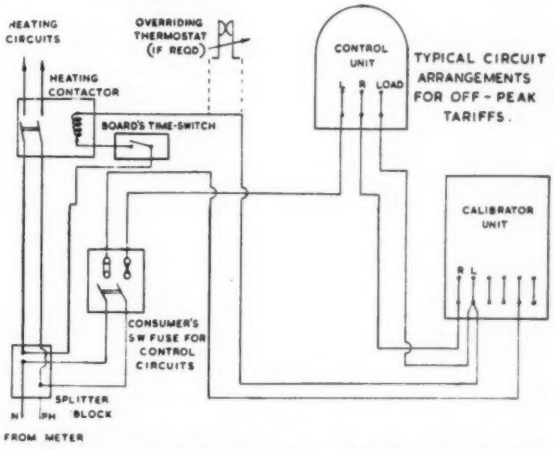
Such a temperature controller has been designed by the Eastern Electricity Board, and Process Control Gear Ltd. are now manufacturing this controller known as the Proscontroller (patent applied for).

One of the advantages of this controller is that it proportions the charging time throughout the whole available period, and not at either end of the period, as with some other types of controllers. It can thus make allowances for variations in weather conditions at all times during the available charging period. Apart from temperature, it is also sensitive to wind, rain and other weather conditions which affect the heat requirements of a building. The unit is suitable without modification of any kind for the control of floor warming and block type thermal storage installations.

The Proscontroller comprises:

(i) A control unit in a weatherproof box which is freely exposed on the outside of the building to be heated, and contains a thermostat and heating coil

(ii) A calibrator unit which is sited at any convenient place within the building and contains an auto-transformer and variable resistance, by means of which the loading of the heating coil in the control unit is adjusted to the correct value.



Typical circuit arrangement for off-peak space heating installations using Proscontroller

The control unit is virtually a model of the building to be heated, but without the building time lag. The setting of the thermostat within the control unit determines the temperature maintained within the building; whilst the setting of the variable resistance in the calibrator unit determines the loading of the heating coil in the control unit, and hence the range of temperature covered by the controller between full charge and no charge.

The temperature controller must not be used to control the heating circuits directly, even for loads of less than 3 kW, but must be arranged to operate the coil of a relay or contactor which, in turn, switches the heating circuits.

Circle **43** *for further details.*

True R.M.S. Wide Band Voltmeter

THE Cossor Type 1453 true r.m.s. wide band voltmeter is designed to indicate true r.m.s. voltage readings over a wide frequency range, regardless of waveform, at the

True r.m.s. voltmeter

Electronic modulator

same time having the high input impedance normally associated with a valve voltmeter. With the exception of the thermo-electric type of instrument, r.m.s. calibrations on wideband a.c. voltmeters have hitherto applied only when measuring sine wave quantities. Since the reading of the thermo-electric instrument is proportional to the average heating effect of the current being measured, true r.m.s. values are indicated regardless of waveform. The limitation of low input impedance is eliminated in Model 1453 by preceding an h.f. vacuo-junction by a gain-stabilised wide band amplifier.

Readings are indicated on a 3½ in. meter which is calibrated with three scales, two for voltage and a third marked in decibels. The voltage scales are calibrated 0–30 and 0–100. Reference level of the dB scale is 1 mW in 600 ohms.

Full scale voltage range is 30 mV–300 V r.m.s., in nine switched steps each of 10 dB. On ranges 30 mV to 10 V inclusive, the maximum amplitude variation at 20°C is ±0·6 dB over the frequency range 50 c/s–10 Mc/s. On the remaining three ranges, the response falls gradually, being not more than 1·5 dB down at 10 kc/s, relative to 1 kc/s.

Switched input impedances of 1 M ohm, 600 ohms and 75 ohms are available, each shunted by a nominal 70 pF. In addition, facilities for external termination are provided on the front panel. Values of external termination are always shunted by 1 M ohm and 70 pF. With all input arrangements the signal return may be either earthed or floating.

A built in high pass filter is provided which can be used to eliminate mains hum from high frequency signal voltages. The filter can be switched in, on all ranges, with any of the input arrangements and provides 1 dB attenuation at 3 kc/s, 6 dB at 1 kc/s, with a slope of approximately 6 dB per octave.

A typical application is to measure the r.m.s. value of receiver "grass" (or noise)—a measurement hitherto only estimated from a reading of peak-peak value on a c.r.t. screen.

The instrument is adequately stabilised against mains input variations and is temperature compensated. For a ±7% change from the nominal mains supply voltage, the meter reading changes less than 0·2 dB at 1 kc/s. The temperature coefficient is positive, giving an error of +0·2 dB at 50°C.

Model 1453 is suitable for use on 110–250 V a.c. 50 c/s or 400–500 c/s. Power consumption is in the region of 25 W. The Services approved version has the reference No. CT 454.

Circle **44** *for further details.*

Electronic Modulator

A TRANSISTORISED chopper, electronic modulator SM 10, is now available from TMC. Designed and manufactured by Bailey Meters and Controls and marketed by Telephone Manufacturing Co., the price of the component in the U.K. for small quantities, available from stock, is £8 5s. 0d.

Model SM 10 is a small, highly stable, silicon transistorised chopper designed for low level d.c. chopping. Of the directly coupled type, it offers designers the simplest form of clamp-type chopper with which to solve circuit problems.

Since all the components are encapsulated within an aluminium can the unit is virtually immune from vibration and shock effects, making it an ideal component for commercial, scientific or military purposes. Unlike mechanical choppers, it has no moving parts to suffer wear, or contacts to become contaminated and it never needs adjustment. Moreover, it is highly stable over a wide temperature range.

Driving voltages:	Sinusoidal or square wave 6 V ±25% (current approximately 14 mA at 6 V)
Driving (chopping) frequency:	40 c/s to 1,000 c/s
Input voltage:	1 μV to 250 mV
Output voltage:	Equals chopped input voltage to better than 1%
Operating temperature range:	0 to 55°C
Output temperature coefficient:	Average 1 μV per °C Maximum 2 μV per °C
Switching transients:	Extremely low. At 1 mV level total duration is only 15 μs at 400 c/s.

Circle **45** *for further details.*

Wire Stripper

ROTO-FINISH LTD. have introduced a new product, wire stripper 493, for stripping baked enamel insulation

and synthetic coatings from wire and from vertical or other large surfaces. This process is particularly suitable for use on, for example, commutators, motor windings or any insulated electrical windings.

The method of use is simple. The stripper is applied to the coating to be removed, which is left until it lifts, and then wiped clean. Roto-Finish 493 diluent is used to adjust the viscosity of the 493 stripper when very thin wires are being stripped or when the 493 stripper becomes too viscous, due to long exposure.

Circle **46** *for further details.*

Double Triode Valve

A NEW G.E.C. double triode valve, Type A2900, has been introduced by the M-O Valve Co. Ltd. This valve is fitted with the B9A base and it has been designed to replace the international Type 12AT7, particularly in computer and switching applications where long life and reliability are essential. Since the characteristics are similar in many respects to the 12AT7 and dimensions and base are also alike, no circuit modifications are required in the majority of applications.

Key features of this new valve, of special interest to designers of industrial equipment, are a close control of characteristics and a life expectancy of up to at least 10,000 hours under approved working conditions.

Anode current differences between the two triode sections will not exceed 1·25 mA over a mean average spread of 10·5 ± 1·5 mA, while mutual conductance between the two systems will not differ by more than 1 mA/V over a mean average of 6·2 ± 0·8 mA/V. This close degree of tolerance in the specification will remove many of the difficulties experienced in these respects by the use of a normal double triode valve.

A guarantee exists for the A2900 covering lives up to 10,000 hours.

Circle **47** *for further details.*

Multirange Chart Recorder

THE Norma portable multirange current and voltage recording and indicating instrument is now available in this country through Croydon Precision Instruments Ltd.

This instrument has 20 ranges and can be used with both a.c. and d.c. The limits of error are ±1·5% of the maximum scale value assuming sine wave. The recording instrument conforms with specifications laid down in B.S.90 : 1940, with the exception of Appendix D. The rated frequency is 15 to 100 c/s. The weight is approximately 30 lb.

Circle **48** *for further details.*

Normameter

THE Normameter is a compact Wheatstone bridge suitable for conductivity measurements. The measuring range for resistance is 0·08 to 60,000 Ω and for conductivity 16·7 to 12·5 × 10^6 micromhos divided into six ranges.

Model 185R1 is suitable for measurements on solid conductors and Model 185RW1 for the measurement of resistance of liquids, particularly for the specific conductivity of electrolytes, or for the earth resistance of lightning conductors by the Nippold method.

Sole agents in this country are Croydon Precision Instruments Ltd.

Circle **49** *for further details.*

Miniature Precision Wirewound Resistor

A PRECISION resistor of 10 MΩ ± 0·05%, size 1 × ¼ in. diameter, is announced by Alma Components Ltd. Known as the Type E, the resistor is available from 100 kΩ to 10 MΩ to a tolerance of ±0·05%, and a temperature coefficient of better than ±0·002% per °C. The resistor is wound on a ceramic bobbin and is encapsulated in epoxy resin, providing hermetic sealing from 0°C to +100°C.

Construction: The former is made from non-hygroscopic ceramic with high insulation properties and great mechanical strength. The coating is an epoxy resin, clinging tightly to the former and wire to ensure protection against humidity over the range 0°C to 100°C.

Power rating: ½ watt

Max. voltage: 1 kV

Terminations: Radial or axial lead outs

Stability: Better than ±0·05%

Prices: Same as " Alma " Type L.

Circle **50** *for further details.*

Ultra-violet Hand Lamp

A FURTHER addition to the " Allen " range of ultra-violet lights is a light-weight hand lamp.

This lamp, the " Allen " Type A.405, uses two 9 in. long miniature fluorescent tubes as the source of the 3,650 Å radiation.

The light is always ready for use without delay for warming up and is very efficient with high u.v. output for a consumption of only 20 watts. The tubes run cool and have an average life of 5,000 hours.

The complete unit, including control gear, is available in two forms:

Model A.405
Hand lamp with separate control unit. (9½ × 2½ × 2 in.) For use in factory, mill or laboratory. £16 5s. 0d.

Model A.405/*P*
Hand lamp with polished hardwood carrying case containing control gear and cables. (15 × 8½ × 4 in.) For use on " site ". £19 10s. 0d.

Both models work from 200/250 V a.c. mains (110/115 V models are also available).

Circle **51** *for further details.*

Glass Electrode pH Tester

THIS pH tester, manufactured by L. Siebold, is being made available in this country through The H. G. Stevens Co. Ltd.

It has a measuring range 2 to 12 pH and a measuring accuracy of ±0·1 pH. There is temperature control which can be manually adjusted within the range 5 to 80°C.

The shape of the instrument is such that the sensitising electrodes are attached to the lower end and the indicating meter is built into the top.

The length of the instrument is $18\frac{1}{2}$ in. and the indicating meter is $4\frac{1}{8} \times 4\frac{13}{16}$ in. The weight inclusive of batteries is $3\frac{5}{16}$ lb.

The price is £74 and delivery is six weeks.

Circle **52** *for further details.*

Photomultiplier Tube

MULLARDS' Type 56 AVP photomultiplier tube, with a peak response at 4,200 Å, has now been fitted with a quartz end window, and it has been modified so that the spectral response extends well into the u.v. The new tube Type 56 UVP has a useful response down to 2,300 Å with a peak at 4,000 Å.

For high definition work very small electron transit time differences are essential and in the 56 UVP they have been kept down to 2·0 millimicroseconds at half-pulse height, with a rise time of the same duration.

This substantial reduction of transit time differences is due to the specially designed input electron-optical system in which the photocathode is curved so that the path lengths to the first multiplier stage are approximately equal for electrons leaving any part of its useful area. In fact, the transit time difference between electrons arriving at the first dynode from the periphery of the photocathode and those arriving from the centre is only 0·3 millimicroseconds.

Uniformity of transit times through the 14 multiplier stages is maintained by careful shaping of the dynodes, and by the additional focusing electrodes situated between each multiplier stage, which progressively narrow the electron beam from stage to stage despite the rapid growth in the number of electrons.

The 56 UVP is available in limited quantities.

Photocathode (end-viewing)	
Minimum useful diameter	42 mm
Peak spectral response	4,000 Å
Average sensitivity	50 μA/lumen
Multiplier (14 *stage*)	
Minimum gain (at total supply voltage of 2 kV)	10^6
Maximum peak anode current	1A
Average anode sensitivity (at 2 kV)	5,000 A/lumen
Dark current (at gain of 10^6)	less than 5 μA
Output pulse (at total supply voltage of 2 kV)	
Rise time	2 mμA
Width at half height	2 mμA
Mechanical	
Maximum overall height	190 mm
Maximum seated height	175 mm
Maximum diameter	55 mm
Base	20-pin (bidecal)

Circle **53** *for further details.*

Tangential Flow Fan

THERE is a barrier to the efficient movement of air at low speeds which can be termed the "stall barrier". All domestic fans operate in this region. Their blades have to operate on air initially at rest, and much of their surface is used in ineffectually churning this up before it can be induced to slide past the outflow.

In the Firth Cleveland fan heater unit the vortex is set up by the cylindrical impeller and the vortex-former, which is an L-shaped barrier set at an angle and running the length of the impeller. When the unit is switched on the blades of the impeller draw in air at right angles through the louvres above it. The presence of the vortex-former sets up a cylindrical vortex of air positioned between the inlet and outlet ducts with its axis parallel to the axis of the unit. The shape of the vortex-former stabilises the centre of the vortex a very short distance from the inner edges of the impeller blades. Consequently the vortex rotates with a high angular velocity. Its circumference, which is moving at a high speed, couples with the input and output air streams and pulls them past the blades of the impeller with a greater velocity than the peripheral speed of the blades.

In this manner a high air velocity is achieved with a low peripheral blade speed, and, as the blades are transversed twice, more throughput per frontal area is obtained from this than from any other air-circulation unit. This high velocity enables a powerful heater to be used without increasing the temperatures of the output to an uncomfortable level.

The noise output of a fan increases approximately according to the 5·5th power of the speed of the blades. Because the impeller blades are running at a much slower speed than in the conventional fan, the noise is reduced to be nearly inaudible.

When a heating action is desired, the heating element is formed as a helix of edge-side-wound metal ribbon, and is supported on an insulating cradle in such a way that it cannot collapse at any working or emergency temperature. The unique construction of the heater element combines a high surface ratio with a rigid and reliable construction.

The fan directs the stream of directional non-turbulent air through the heating elements at the output duct of the heater whence it emerges in a smooth, long, powerful flow which travels at least 15 feet before it is broken by convection. The heating element is operated under black conditions yet generates over 2 kilowatts of heat.

Circle **54** *for further details.*

Quartz Crystals

STANDARD TELEPHONES & CABLES LTD. has developed a range of small low-frequency crystals for use in miniature equipments. These units are in evacuated glass envelopes of 0·4 in. diameter and have wire leads. Their length is dependent on frequency as follows:

Frequency Range	STC Type	Maximum Length of Envelope
57– 62·9 kc/s	4432	2·83 in.
63– 71·9 kc/s	4438	2·44 in.
72– 99·9 kc/s	4437	2·04 in.
100–150·0 kc/s	4435	1·45 in.

Accuracy ±0·01% at 24°C
Stability ±0·2% from −20 to 70°C.

Small quantities of these crystal units are available now and they will be in full production by the middle of 1961.

It is intended to extend the frequency range of this type down to 10 kc/s in the future to replace types using the current B7G mounting.

Circle **55** *for further details.*

Circle **366** for further information

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Power Pack

THE Racal power pack PU.156C provides an economic means of ensuring a stable h.t. supply for various uses in radio and electronics, for laboratory work, or for incorporation in industrial production and test equipment.

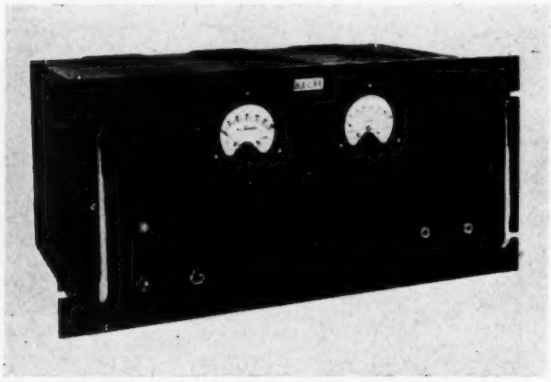
With a positive d.c. voltage in two ranges, +200 to 250 V and +250 to 300 V, the PU.156C provides an h.t. output of 0–250 mA. Input regulation is 0·1% for ±6% mains voltage variation and the ripple voltage is 8 mV r.m.s. A negative stabilised h.t. voltage of −150 V gives a d.c. current of 15 mA and the total regulation is 3% total change in voltage for load-change from 0–15 mA and mains voltage change within ±6%.

The PU.156C also provides an a.c. output (unstabilised) of 4 or 6·3 V at 3 A or 6·3 V at 2·5A.

The Racal power unit, which operates from 200–250 V, 45–60 c/s mains supply, can be supplied as a basic unit for incorporation with other equipment, or for rack mounting. In this version, known as the PA.47/1, the unit is fitted to a standard 19 in. front panel with terminals, meters, fuses. Voltage and current are metered separately, and h.t. settings are determined by one control on the front panel.

Price: ex works — PU.156C — £35 0s. 0d. PA.47/1 — £63 0s. 0d. Deliveries from stock.

Circle **56** *for further details.*



Power pack

Transistors

THE following new types of transistor have been introduced by Standard Telephones & Cables Ltd.:

TK250A—A silicon diffused n-p-n transistor for fast switching at current levels of up to 250 mA, or as a driver for high frequency power oscillators working at frequencies of up to 10 Mc/s.

Current and voltage ratings are as follows:

V_{CB}max	Maximum collector-to-base voltage with emitter open circuited, or reversed biased	40 V
V_{CE}max	Maximum collector-to-emitter voltage with base open-circuited ...	20 V
V_{EB}max	Maximum emitter-to-base reverse voltage	6 V
$I_C$max	Maximum collector current	0·25A
$I_E$max	Maximum emitter current	0·285 A

The TK250A conforms to the following outlines:

VASCA: SO-3
K1007: A1/D3A
JEDEC: TO-9.

Sample quantities of the TK250A are available and data sheets will be sent on request.

TK48C—A germanium alloy junction p-n-p transistor designed for use in telephone exchange switching systems where the use of relays demands a transistor with comparatively high voltage ratings. The collector-to-base rating, V_{CB}max, is 60 volts and the collector-to-emitter rating, V_{CE}max, is 20 volts. An advance data sheet is available.

Circle **57** *for further details.*

Rectifiers

Two new, low-cost, silicon rectifiers for light industrial applications have been added to Standard Telephones & Cables Ltd.'s 'FST' range. Known as the FST 1/0 and the FST 1/1, these are 50-volt and 100-volt diodes respectively.

The FST range is composed of plastic-encapsulated, half-ampere silicon rectifiers.

The existing range of miniature selenium rectifier assemblies manufactured by the Rectifier Division has been extended. The previous range of miniature rectifiers included the 'M' type and the 'Q' type and 'MQ' Unistor. The term 'Unistor' has now been dropped and the range widened to comprise the types below:

Type	Description	Remarks
M	Single plate in aluminium case	Half-wave device fitted to axial leads (Plate types 1 or 3)
T	One plate or two plates in aluminium case	
Q	Up to five plates in series in moulded nylon case	Half-wave devices fitted to axial leads (Plate types 1, 3, 6, 8 or 9)
MQ	As for M but hermetically sealed and tropicalised	
P	Up to five plates in moulded rectangular plastic case shaped for automatic insertion	Available in half-wave, doubler, push-pull or bridge configuration with multiple leads. (Plate types 1, 3, 6, 8 or 9)
R	Is a skeleton form of type P for use in restricted space	
L	Cylindrical case in two sizes for up to ten or up to twenty plates	

These SenTerCel selenium rectifiers are designed for use in electronic circuits calling for a diode of good reverse/forward resistance ratio and closely controlled characteristics. Being of small size, they are easily accommodated in circuits and are suitable for most applications, including modulators and demodulators, discriminators, logical circuits, limiting diodes, asymmetrical resistors, etc.

Circle **58** *for further details.*

Synchro Trainer for Automatic Control

AN aid to education and training in the fundamental principles of automatic control, the synchro trainer has been produced by the Servokits Division of Pioneer Designs Ltd.

Data transmission, synchronous links and simple computing problems may be illustrated using the synchro trainer, and the student can study the effects of interchanging the rotor and stator connections of different types of synchros in a variety of arrangements.

The synchro trainer is entirely self-contained, having two internal 50 V, 50 c/s supplies, separately fused, brought out to four pairs of sockets on a control panel from which random connections may be made to the rotors and stators of six synchros fitted as independent units below.

Each equipment is supplied with two control transmitters, one control transformer, one control differential transmitter, one resolver and one torque differential receiver. These are all standard Admiralty pattern 3 in. 50 c/s synchros and their rotor and stator connections are brought out to sockets on the front panels of their individual units.

Interconnections between power supply sockets on the control panel and synchro units are made with leads supplied fitted with 3 mm plugs. With the exception of the torque synchro which has provision for attaching spring balances or weights for torque measurement, the remainder of the synchros are fitted with 3 in. diameter dials, and rotor locking devices.

Causes of simple faults can be demonstrated, and much of the ground-work for servomechanisms taught with a minimum of equipment and effort.

Circle **59** *for further details.*

Vacuum Switch Relay

A VACUUM switch relay with a.c. and d.c. versions, Type J.55 and J.05, have been added to the B. & R. Relays Ltd. range. This vacuum switch model has been developed from the original J.01 type.

The relay may be fitted with either one or two make or break vacuum switches, although where only one vacuum switch is required, standard silver contact assemblies may be incorporated. The vacuum switches are operated by the electro-mechanical operation of the relay itself. Connection is made through a sensitive metal diaphragm sealed inside the glass envelope of the switch. Switching rate is three operations per second, operating position is universal, and the relay weighs approximately 8 oz.

Circle **60** *for further details.*

Recorder Control

THE Cahn recorder control converts any fixed-span recorder to a universal multirange recorder, with 15 voltage ranges and 15 current ranges. It greatly increases the versatility of existing recorders in the fields of electronics, chemistry, and physics, in research, production and other operations. It can be used directly with all types and makes of potentiometric recorders, and d'Arsonval recorders with vacuum-tube pre-amplifiers.

The recorder and signal are plugged into the recorder control, and the range switches set for the recorder span desired. Precision resistors preserve the original accuracy of the recorder on all ranges, and can be used as resistance standards themselves. The recorder zero can be checked during a long run without disconnecting or disturbing the signal, and polarity can be reversed with a panel switch.

The Cahn recorder control can readily be interchanged between different recorders, and added to existing recorders.

Full-scale ranges of 10 mV to 500 volts, and 10 μA to 500 mA in convenient 1-2-5-10 sequence, are selected with a 10 mV recorder. For other recorder spans these ranges are multiplied by the ratio of the span to 10 mV. Input resistance is 100,000 ohms per volt with a 10 mV recorder, 1 megohm per volt with a 1 mV recorder. Input resistance for current measurement varies from 1,000 to 10 ohms, depending on range. Output resistance is 1,000 ohms or less, suitable for all potentiometric recorders.

The Cahn recorder control can also be used with oscilloscopes, providing more accurate calibration and more convenient ranges than are available on most models.

Circle **61** *for further details.*

Teraohmmeter

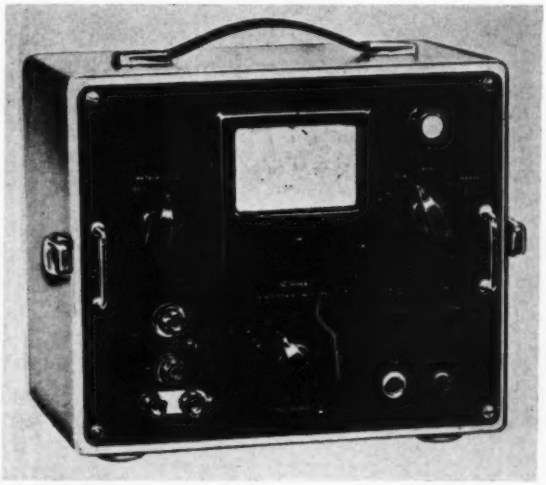
THE teraohmmeter Model 266T is a portable insulation test set suitable for measuring the insulation resistance of electrical components of all kinds. Its overall range is 0·6 MΩ to 500 TΩ and there are 28 ranges available. Two test voltages are available of 100 and 500 volts and the instrument has built-in accuracy control.

The scale length is 2·75 in. and the dimensions with the lid is 11 × 9 × 9 in. and the weight is 17 lb.

The accuracy is 2·5% of scale length with ±2% for ranges ×1 to $\times 10^4$ and ±5% for ranges $\times 10^5$ to $\times 10^6$.

Sole agents in this country are Croydon Precision Instrument Co.

Circle **62** *for further details.*



Teraohmmeter

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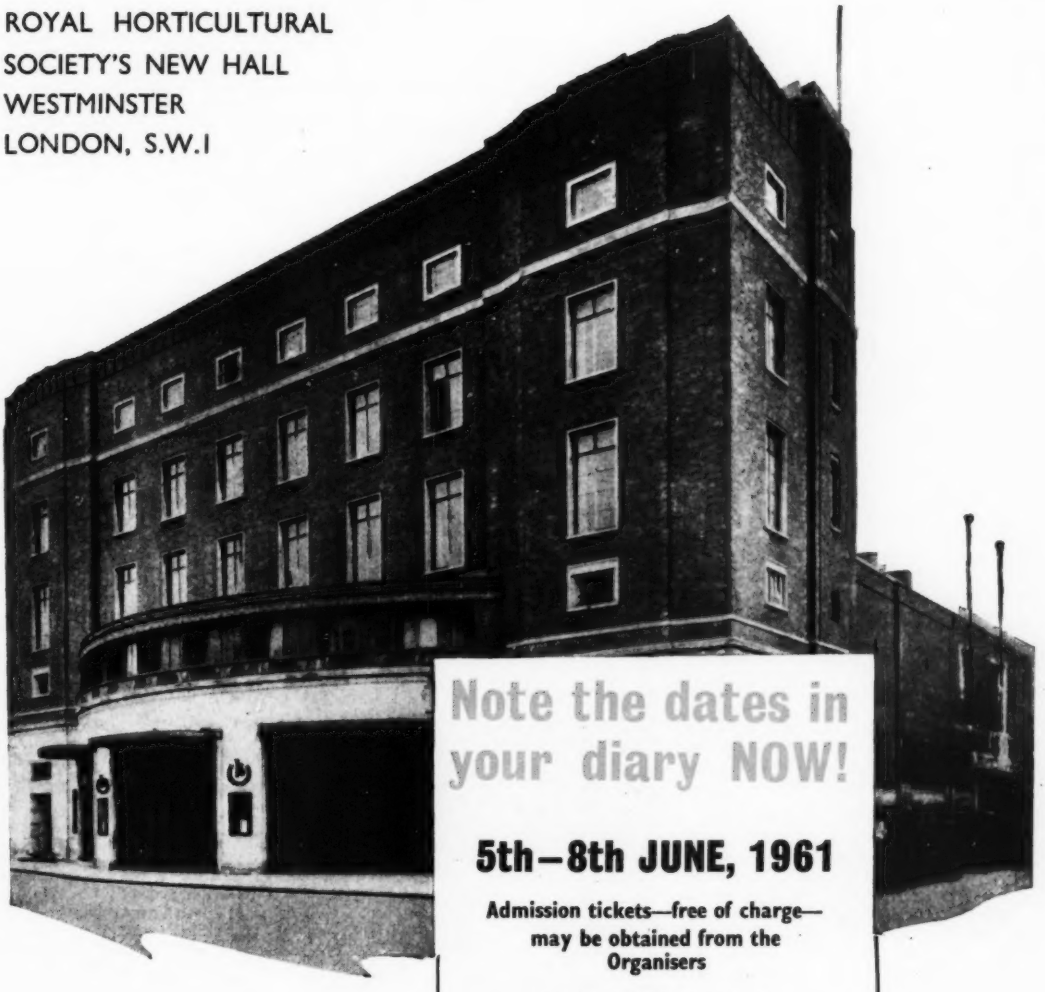

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Items of Interest at the

RADIO AND ELECTRONIC COMPONENT SHOW

The 17th Radio and Electronic Component Show is being held at Olympia from 30th May to 2nd June. The Component Show has grown too big for Grosvenor House, Park Lane, where it was held for many years and this year there will be more than 250 exhibitors.

During 1960 the output of the British radio and electronic component industry increased by more than 10% over the previous year. This figure does not include valves, transistors and cathode ray tubes. Exports of components increased by 36% over the same period.

The Federation estimates that the output of the whole radio and electronic component industry is approximately £400 million.

Apart from the actual components, there will be exhibits of applications of components and we have picked out some items likely to be of interest.

Amplifiers

A high gain twin channel pre-amplifier for use with their D31 double beam oscilloscope will be shown by **Telequipment Ltd. (497).** This pre-amplifier, Type P.A.2, has two independent amplifiers, each having a gain of 100, giving a maximum sensitivity of 1 mV/cm on each channel. By using the amplifier in conjunction with the S.42 the sensitivity is increased to 100 μV.

Audio amplifiers and amplifiers with power outputs in the range 10 to 300 watts will be exhibited by **Whiteley Electrical Radio Co. Ltd. (56).**

Arrell Electrical Accessories Ltd. (207) will be including among their exhibits amplifiers with gains from 20 to 70 dB and power outputs up to 3 V into 80 ohms. These amplifiers can be supplied for wall or standard 19 in. rack mounting.

A travelling wave tube power amplifier TWC5 capable of delivering 15 W in the 5,925 to 6,425 Mc/s band will be shown by the **M-O Valve Co. Ltd. (163).**

Computers, Recorders, Controllers

A thermionic eight speed data deck designed primarily for digital recording on up to 20 tracks and playback at speeds from ¼ in./sec to 15 in./sec will be shown by **Thermionic Products (Electronics) Ltd. (106).** There will also be a selection of recording and playback heads for domestic and professional recording, and a multichannel recorder Series III for communications recording on up to 20 tracks.

A photo-electric controller will be shown by **Measuring Instruments (Pullin) Ltd. (55).**

Wayne Kerr Laboratories Ltd. (485) will be demonstrating their transfer function computer SA100 measuring the transfer function of active and passive networks.

The transistorised data logger/alarm scanner, Type 300, will be exhibited by **Microcell Electronics Ltd. (230).**

The equipment is unique in that some of the "building bricks" made by other suppliers are used in the system. Only units which are well proven have been chosen, the remaining "bricks" being developed and manufactured by Microcell; the complete apparatus is systems engineered and custom built by Microcell.

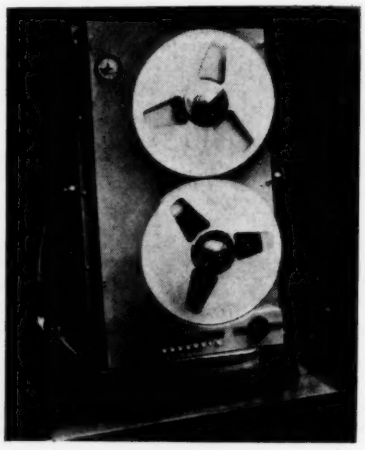
Generators and Oscillators

Dawe Instruments Ltd. (212) will be showing white noise generators, Types 419B and 419BR. Three bandwidth ranges are provided covering 30 c/s to 20 kc/s, 30 c/s to 500 kc/s and 30 c/s to 5 Mc/s respectively. Type 419B is designed for bench mounting and Type 419BR for mounting in a standard 19 in. P.O. rack. The maximum output voltage is approximately 1 V r.m.s. and the output impedance approximately 1,000Ω.

Among the oscillators to be shown by **Dawe Instruments Ltd. (212)** are: Type 421 transistorised audio oscillator with a frequency coverage from 20 c/s to 20 kc/s. The output is variable from 2·5 V r.m.s. into 600 Ω: Type 441 wide range oscillator tunable from 5 c/s to 600 kc/s in five ranges. The output level is continuously variable over a range of at least 20 dB by means of a bridged-T attenuator to provide a constant source impedance of 600 Ω.

Oscillators using their own components will be shown by **Whiteley Electrical Radio Co. Ltd. (56).**

Audio oscillators, short duration pulse generators, video oscillators, and portable frequency standards will be shown by **Wayne Kerr Laboratories Ltd. (485).**



Thermionic eight speed data deck (Thermionic Products)

Heating Equipment, Ovens

A radiant zone heater capable of temperatures in excess of 1,200°C will be exhibited by **Electrothermal Engineering Ltd. (204).** This heater has many applications, including zone refining.

Temperature-controlled ovens will be shown by **Cathodeon Crystals Ltd. (362).** These are suitable for close temperature control of temperature sensitive devices. Control is by mercury or bimetal switch.

Instrument Housings

Additions to their range of instrument housings and accessories will be shown by **Alfred Imhof Ltd. (159).** These include the Imlok construction system which can take glass of varying thicknesses or plywood up to ¾ in. thick, also a series of extrusions and connectors known as the T.P. series. There will be two additions in the Imrak range, the Imrak electrical cubicle and open Imraks.

Thermo Plastics Ltd. (209) will be exhibiting cabinets, mouldings, p.v.c. and synthetic products. Casings produced from glass-reinforced materials, and shapings from Perspex, cellulose acetate, high impact styrene will also be exhibited.

Manufacturing Equipment

Bader Machinery Co. (494) will be showing equipment for the manufacture of semiconductors, incandescent lamps, fluorescent tubes, radio valves and television tubes.

Production, miniature and G.P.O. type low voltage soldering irons and soldering equipment will be shown by **Electrical Remote Control Co. Ltd. (411).**

Measuring Equipment

Greencoat Industries Ltd. (111) will be exhibiting a portable tachometer unit measuring between 1 rev/min and 20,000 rev/min with an accuracy of 0·02%.

Among the measuring instruments to be shown by **Marconi Instruments Ltd. (314)** are the following new instruments:

(a) A wide band millivoltmeter, Type TF 1371, with frequency range 30 c/s to 30 Mc/s and voltage range 100 μV to 300 mV or up to 30 V with optional multiplier.

The TF 1371 will measure small a.c. voltages from power-supply frequencies to the threshold of v.h.f.; it can be used on r.f., i.f., video and audio amplifiers; and it allows measurement of signal levels

throughout h.f. receivers, from aerial to loudspeaker. Its 5½ inch meter responds to the average value of an a.c. waveform and is calibrated in the r.m.s. value of a sinewave; it has two millivolt scales, and a scale showing decibels relative to 1 mW in 600 ohms. To maintain long-term accuracy, the calibration can be easily standardised against an internal source.

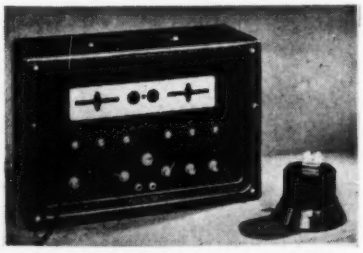
(b) The precision crystal calibrator Type TF 1374 covers the frequency range 100 kc/s to 1,500 Mc/s. It provides check points in the form of headphone zero-beats at intervals of 10 Mc/s, 2 Mc/s, 500 kc/s or 10 kc/s. In the alternative version, Type TF 1374/1, the 10 kc/s check points are replaced by 25 kc/s points which are usable up to 200 Mc/s.

(c) The TF 1067 is a heterodyne wavemeter with a frequency range of 100 kc/s to 100 Mc/s. It employs a precision linear tuning system and has an accuracy of 0·01%. The dial is directly calibrated and allows positive indentification of more than 400 crystal check points; no calibration charts are required. The Type 1067/1 is an alternative version covering the frequency range 5 Mc/s to 1,000 Mc/s.

The new Crystal series of ammeters and voltmeters with optional colour coded covers will be featured by **Measuring Instruments (Pullin) Ltd. (55)** together with several rectangular panel instruments with fully transparent covers and different types of movement.

Wire Products Ltd. (490) will be showing the Sterimag stereoscopic microscope. This microscope has ×10 and ×20 magnification and is priced £34.

In the display of **Wayne Kerr Laboratory Instruments (485)** will be six bridges which provide comprehensive measuring facilities for conductance, capacitance and inductance from 60 c/s to 250 Mc/s.



Universal bridge B221 and low impedance adaptor Q221 (Wayne Kerr)

Motors

A range of 3 pole and 6 pole Kinder d.c. motors suitable for driving servomechanisms, echo sounders, battery operated record player units, etc., will be shown by **Greencoat Industries Ltd. (111).**

A range of T.I.M. f.h.p. shaded pole a.c. motors will be displayed by **Mycalex & T.I.M. Ltd. (253)** together with a combined motor/transformer, and a range of higher powered four pole motors known as the MJ series.

Power Supplies

Power supply units using toroidally wound components will be shown by **Aveley Electric Ltd. (360).** They comprise a range of a.c. to d.c. converters, d.c. to a.c. inverters and a transistorised klystron power supply.

A power supply unit will be among the exhibits of **Thermionic Products (Electronics) Ltd. (106).**

Type 410 power supply from **Microcell Electronics Ltd. (230)** is a bench-type supply, providing a continuously variable output voltage from 1-30 V with an output current of 5 A. Voltage levels are adjusted by a variable ratio transformer producing high reliability and repeatability. Output voltage and current are monitored on a built in meter and a rapid-acting cut-out protects the supply and the external circuit should overloading occur.

Production Equipment

A new automatic printing machine for components with coaxial leads will be shown by **Rejafix Ltd. (359)** which incorporates a new feeding mechanism. Articles can be marked with either letter or figure coding, or can be colour coded. Special machines for colour banding and an improved model of the transistor printer will also be shown.

Strip terminal attaching machines will be among the exhibits of **Ross, Courtney & Co. Ltd. (493).** One machine and installation head installs over 300 different terminals, and many users of these machines constantly achieve rates of over 4,000 terminal installations per hour.

Temperature Measurement

Mineral-insulated thermocouples will be shown by **British Insulated Callender's Cables Ltd. (156):**

Measuring Instruments (Pullin) Ltd. (55) will be exhibiting their Thermeter, a portable surface thermometer for industry.

Test Equipment

A wide range of test equipment will be shown by the **British Physical Laboratories (479)** including component comparators, breakdown testers, frequency meters, megohmmeters, and resistance voltage coefficient measuring sets. Among new equipment to be shown by the company are:

(a) A low load digital Wheatstone bridge with a resistance range of 1 mΩ to 10 MΩ and accuracy within 0·1%.

(b) Component comparator with a high speed Automator which, when coupled to the comparator, will enable testing speeds up to 6,000 components per hour to be maintained.

Two other comparators will be shown, one suitable for high speed checking of electrolytic capacitors, Model CZ 961, and one suitable for checking ceramic capacitors, Model CZ 960.

Among exhibits of **Zenith Electric Co. Ltd. (257)** will be insulation flash testing equipment for industrial and domestic equipment.

Vibration test equipment will be exhibited by **Goodmans Industries Ltd. (264).** The VG.108 Mk II vibration generator will be shown as a working model with a PA 2 kVA power amplifier.

Precision measuring oscilloscopes, Types S31 and S42 will be shown by **Telequipment Ltd. (497).** The S31 is a portable oscilloscope with a 3 in. flat-faced tube operating at a high e.h.t.

The S42 is particularly useful for applications involving high writing speeds at low repetition rates.

An impedance comparator, Type 304, designed for the rapid testing of resistors, capacitors and inductors, will be shown by **Dawe Instruments Ltd. (212).** The component ranges are: Resistance 10Ω to 5 MΩ; Capacitance 100 pF to 10 μF; Inductance 2 mH to 100 H.

The company will also be showing their transistor circuit equipment, the a.c. Milliclamp Type 618. This enables a.c. to be measured with a valve voltmeter, or examined with an oscilloscope without circuit interruption. The frequency range is 7 c/s to 1 Mc/s; current range up to 10 A r.m.s. and accuracy ±3% at 1 kc/s above 1 mA.

Multi-range meters and test-sets, cable fault locating and cable indentification equipment will be shown by **Whiteley Electrical Radio Co. Ltd. (56).**

The **London Electrical Manufacturing Co. Ltd. (311)** will be showing an impulse voltage proof test equipment which is the first in a new range of electronic test equipment from the company.

A five dial Wheatstone bridge with overall accuracy of 0·005% will be introduced by **Rivlin Instruments Ltd. (407).**

The dielectric test set, Type 441 from **Microcell Electronics Ltd. (230)** can be used to provide information on the behaviour of ceramics, plastics and allied materials when submitted to the influence of microwave frequencies and high temperatures.

This model is available within the frequency range 8,800 Mc/s-9,750 Mc/s and the built-in oven enables measurements to be made at sample temperatures up to 400°C.

Transistor analyser Type 440, which will be shown by **Microcell Electronics Ltd. (230)** is designed to measure to a high degree of accuracy the parameters of p-n-p and n-p-n transistors.

Transformers

Hermetically sealed and open " C " core transformers and open type laminated transformers are among the ranges to be shown by **Gresham Transformers Ltd. (460).** These transformers have been granted full Inter-services Type Approval to Humidity Class H.1. of RCS.214. Other transformers to be exhibited by the company include American transformers for which the company is an approved manufacturer to MIL-T-27 and J.C.N.A.A. F.19.

Power, current and ratio transformers will be shown by **Aveley Electric Ltd. (360)** and demonstrations will be given of testing for the balance low level performance of transistor driven low frequency toroidal chopper transformers.

The transformers exhibited by **English Electric Ltd. (221)** will include a range of ring cores and current transformers; a

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range of single-phase " C " cores hermetically sealed, dry type and resin cast transformers and chokes and three-phase dry type " E " core transformers.

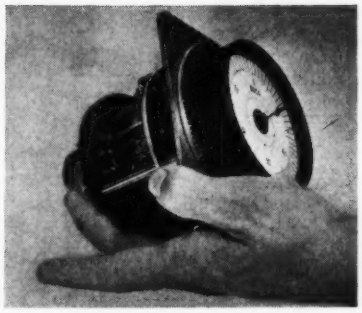
A selection of Variac transformers will be displayed on the stand of **Zenith Electric Co. Ltd.** (**257**) together with fixed ratio transformers and a small portable phase shifting transformer for three-phase operation rated at 200 VA.

Transistorised Instruments

Among the range of transistorised instruments to be shown by **Venner Electronics Ltd.** (**496**) will be their digital volt/ohm meter and their frequency and time measuring equipment.

The digital volt/ohm meter is designed to evaluate d.c. and a.c. voltage from 1 mV to 1,100 V or resistance up to 1·1 MΩ and presents the answer in digital display form. The frequency and time measuring equipment can measure frequency up to 1·1 Mc/s, period, and time intervals in microsecond and larger units. Like the meter, it can be supplied with units to operate a printer or reperforator.

A wide range of transistorised instruments will be shown, a few of which are mentioned below.



Automatic reset dial timer (Elremco)

Dawe Instruments Ltd. (**212**) will be showing their Type 1400 E transistor sound level meter, which has been designed to meet the proposed I.E.C. specification and has a sound level range of 24 dB to 140 dB over the standard reference level of 0·002 dyn/cm². It is battery operated and incorporates networks to give the standard I.E.C. weighting curves and has input, output and passive filter jacks.

Timers and Counters

Electrical Remote Control Co. Ltd. (**411**) will be showing process timers, continuously cycling and resetting multi-circuit shaft timers, automatic reset dial type timers and solenoid escapement timers.

A new square-cased synchronous counter will be exhibited by **Measuring Instruments (Pullin) Ltd.** (**55**).

Miscellaneous

Jackson Brothers (London) Ltd. (**263**) will be showing a simple slow-motion dial based on the epicyclic ball drive. It is designed to mount on the face of the panel and so takes up no space inside the equipment. It can be fitted to any variable capacitor, potentiometer, etc., and is normally supplied with a 1–100 scale. The drive ratio is approximately 6 to 1.

Beulah Electronics Ltd. (**152**) will be showing their D805 studio closed circuit television which has been developed in conjunction with a number of programme contractors of the I.T.A.

Precision brazing equipment will be shown by **Electrothermal Engineering Ltd.** (**204**) to demonstrate the techniques of time and wire brazing.

MANUFACTURERS' LITERATURE

Potentiometer Terms

A 6 page glossary of potentiometer terms is available from Computer Controls Ltd., issued as Technical Note 100A.

As well as stating definitions for each term, the practical value of one definition versus another is stated in terms of " application-sense ".

Circle **63** *for further details.*

Transistors

Details are given of Sylvania Thorn transistors in the latest literature available from the company. The Sylvania Type 2N711 p-n-p diffused base germanium mesa transistor is described in detail. A list is given of types of Sylvania transistors available, their application, rating and characteristics.

Circle **64** *for further details.*

Crystal Controlled Timing Equipment

Communication Systems' crystal-controlled timing circuits are described in their latest catalogue.

Typical accuracy figures for these timing circuits are as follows:

1 part per million from 10 to 30°C
3 parts per million from 0 to 45°C
5 parts per million from −10 to 55°C

Oven-controlled timing equipment, now in the process of development, will offer a minimum of 1 part per hundred million under normal operating conditions.

Circle **65** *for further details.*

Noble Metal Thermocouples

A third edition of " Noble Metal Thermocouples ", by H. E. Bennett, F.I.M., has been published by Johnson Matthey. The book describes the development of the noble metal thermocouple, its applications in steelworks, foundries, and glassworks, and methods of calibration. Curves of temperature against e.m.f. are given for many types of couple incorporating alloys of the platinum group metals, and a chapter describes the chief causes of deterioration in service.

A new feature of the present edition is a short section summarising the behaviour of the many thermocouple combinations that have been proposed from time to time, and recommending those most suitable for particular applications.

The book is available free on application to Johnson, Matthey & Co., Ltd.

Circle **66** *for further details.*

Spire Speed Nut Manual

A new Spire Speed Nut Manual is now available from Simmonds Aerocessories Ltd. This latest edition includes all the more recent developments in their range of spring steel fastenings.

The pictorial index at the front includes additions to the range of parts, such as weld nuts, push-on fixes for rectangular studs and for applications where rotational conditions preclude the use of the conventional type, moulding clips and linkage clips. A numerical index has also been included, together with tables showing the weight per 1,000 for each part, and useful conversion tables.

For the convenience of overseas customers, editions of the Manual have been prepared with the introductory matter and specifications in French, German, Italian, Finnish, Norwegian, Dutch and Danish. Metric dimensions are given throughout all editions.

Circle **67** *for further details.*

Automatic Timer

The ElremCo automatic timer described in list 130 has been designed to meet the majority of common industrial control applications requiring single circuit timing. The price of the unit is £12 18s. 0d.

Circle **68** *for further details.*

Mallory 3 Seam-Welding Blanks

Johnson Matthey announce that a wider range of rough-machined seam-welding wheel blanks in Mallory 3 can now be supplied from stock.

In the interests of international standardisation, the blanks are now available in metric sizes, as recommended in B.S. 3067. The new range includes all the commonly used sizes listed in the specification, and the metric sizes are very close to the superseded inch sizes.

Details of the new range of sizes are given in leaflet 7200/3, " Resistance Welding Electrode Materials ", obtainable from the company.

Circle **69** *for further details.*

(*Continued on page* **629**)

Circle **369** for further information

MS FLUID FACTS

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?

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- *Low volatility*
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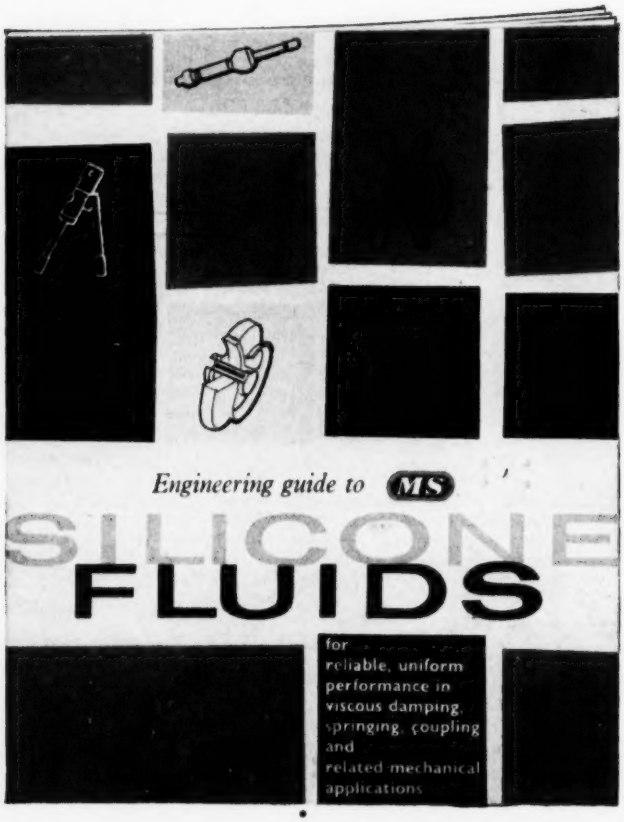
If your requirement is more for silicone lubricants and greases then 'Silicone Lubricating Fluids & Greases' (G 14) *is the publication for you.*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NEWS OF THE INDUSTRY

INSTRUMENTS

BELLING & LEE LTD. have been engaged by Sir Alexander Gibb & Partners, consulting engineers, on behalf of the Air Ministry, to assist in the design and implementation of **r.f. shielding and interference suppression** on the B.M.E.W.S. project at Fylingdales Moor. This installation is to form part of the United States chain of early warning stations, with a range of 3,000 miles, capable of detecting high-trajectory missiles approaching over north polar routes.

The purpose of the shielding is two-fold, to protect operating personnel from the extremely high r.f. radiated power which will be used, and to ensure interference-free conditions of working for all the varied electronic equipment, including the computers, etc., to be housed there. It therefore involves every section of the extensive system of buildings which is being erected, and will necessitate the permanent residence on site of a " Belling-Lee " team of engineers throughout the entire programme of construction.

THE Eindhoven Institute of Technology, Holland, has purchased an expanded 231R **Pace computer.**

The computer, which will be installed at the General Science Division of the Eindhoven Institute of Technology (Professor Rademaker), will feature 60 operational amplifiers and related non-linear equipment (servo multipliers, servo rate resolvers, diode function generators), a high speed transistorised digital voltmeter, etc.

Total cost of the system was about £27,000 and it is the sixth large Pace installation sold in Europe to an educational institution.

ONE of the most important factors in the economic running of steamships is the treatment of boiler feed water supplies, and the vital instrument in the control equipment is the **pH meter.**

Electronic Instruments Ltd. installed pH meters on the new P & O liner ss *Canberra* and this brings their total of pH installations on ships to a hundred.

BRUSH CRYSTAL COMPANY LTD. have **reduced** the **prices** of all their **semiconductor devices.**

In the majority of cases, particularly power and other germanium transistors, reductions of 10% and upwards have been achieved. The silicon devices, particularly transistors, show price advantages of more than 25%.

AN **EMIDEC 1100 data processing system,** supplied by EMI Electronics Ltd., is now in operation at British Motor Corporation's Longbridge factory. This is the second EMI computer now working at Longbridge. It will handle sales invoicing, sales accounting, receipt and analysis of orders, production schedules, sales statistics and stock analysis.

Capable of performing nearly half a million calculations a minute, the EMIDEC 1100 was designed from the outset as a business machine. It is ideally suited for all types of clerical work and provides management with up-to-the-minute statistics in a fraction of the time taken by conventional methods.

THE Pye **argon chromatograph** range of instruments will be exhibited in Moscow from 10th–16th August at the 5th International Congress of Biochemistry.

RADIOVISOR PARENT'S **shipboard smoke density alarm equipment** has been specified by the BP Tanker Co. Ltd. for incorporation in the 50,000 ton tanker now under construction.

ONE of the main reasons for the installation of **automatic boiler control** at the General Hospital of the Birmingham United Hospital Group was to obtain a reduction of smoke emission. During the twelve months the equipment has been in operation, this objective has been realised and the reduced operating costs resulting from a 3·45% increase in boiler efficiency will cover the cost of the equipment within the next six months.

This saving was achieved in spite of a change to a lower grade fuel and represents one-third of the cost of the control equipment.

THE BRITISH MANUFACTURED BEARINGS CO. LTD., of Crawley, Sussex, are carrying out research and development work in connection with **sub-miniature ball bearings** in the form of pivots. These minute, precision bearings can be used as substitutes for jewels used at present in wrist-watches.

Already ball-bearings of this type have been used to replace the jewels in scientific instruments.

COMPANIES

CAPITOL RECORDS INC., a member of the EMI Group of Companies, has launched a large scale entry into the electronics field in the United States.

Hoffman Electron Tube Corporation, of Westbury, New York, and Voi-Shan Electronics Division of Voi-Shan Industries Inc., Los Angeles, have been acquired by Capitol and incorporated in a wholly-owned subsidiary, **Electric & Musical Industries (U.S.) Ltd.**

This new activity in no way overrides EMI's existing agreement with the Fairbanks Whitney Corp. for the marketing in the United States of EMI Electronics' instruments, control systems and closed-circuit television equipment.

EMI/US will manufacture and market a broad line of electronics products in the military, government and consumer fields.

EMI/US will have four divisions:

Broadcast Division, which will market studio equipment, professional tape recorders, and related equipment:

Magnetic Tape Division, which will market video, audio and instrumentation tape:

Electronic Tube Division, which will manufacture and market a full line of special high-performance electron tubes and microwave instrumentation, including photomultipliers, klystrons, travelling-wave tubes, camera pick-up tubes, cathode ray tubes and storage tubes:

Consumer Products Division, which will manufacture and market electronics products for home use.

As a result of the merger between the former Davy United and Power-Gas Groups to form the **Davy Ashmore Group,** the publicity departments of the former groups have been reorganised.

The public relations for the Davy Ashmore Group as a whole will be conducted from Sheffield under the control of Mr. F. R. Smith. General publicity matters will be handled from Stockton by Mr. H. Hopwood.

FOLLOWING the merger of the aviation interests of F. G. Miles Ltd. in the newly formed Beagle Miles Aircraft Co. Ltd., the composition and activities of some of the Miles Group of Companies are as follows:

F. G. Miles Ltd.'s main activity is in the field of precision engineering with particular emphasis on the design and manufacture of small electromechanisms, including control gear.

Miles Electronics Ltd. specialises in the design and manufacture of electronic equipment of all kinds, including aircraft flight simulators, electronic computers, reactor/computer simulators, and nuclear thermal cycling equipment. Current work includes the design and manufacture of the flight simulator for the Royal Navy's new Strike Fighter—The Buccaneer (NA.39).

Miles Hivolt Ltd.'s activities includes research and development in the fields of high voltage direct current supplies,

insulation testers, high voltage impulse generating equipment, small reactors of sub-critical type, and accelerators for neutrons and particles.

Meridian Airmaps Ltd. is principally concerned with aerial photography, photogrammetry and topographical and geophysical survey.

Engineering Laboratory Equipment Ltd., 285 Ealing Road, Alperton, Wembley, Middlesex, has been formed jointly by Soil Mechanics Ltd. (a member of the Mowlem Group of Companies), and Griffin & George Ltd. to provide a comprehensive service at home and overseas in connection with engineering laboratories.

The board at present comprises: Mr. M. W. Leonard, B.Sc.(Eng.)., M.I.C.E., A.M.I.Mech.E.; Mr. A. C. Meigh, M.Sc. (Eng.), A.M.I.C.E., of Soil Mechanics, Ltd., and Mr. F. A. Renn, Mr. H. C. Mayer, F.A.C.C.A., and Mr. D. S. Beard, Ph.D., A.Inst.P., A.R.C.S., of Griffin & George.

The sales manager of E.L.E. is Mr. John Readman, previously on the staff of Griffin & George (Sales) Ltd.; and the technical manager is Mr. T. G. Clark, formerly the laboratory superintendent of Soil Mechanics, Ltd.

THE electronics sections of Armstrong Whitworth Aircraft Ltd. and Brush Electrical Engineering Co. Ltd. have been linked to form a partnership, known as **Armstrong Whitworth/Brush,** to manufacture and market advanced electronic and electrical control and intelligence systems.

Brush will be the trading organisation for the new partnership and will work in close co-operation with the sales staff of Armstrong Whitworth Equipment. Through Armstrong Whitworth/Brush, enquiries for electronic equipment will be channelled to whichever of the two companies has the most suitable facilities. Both Brush and Armstrong Whitworth Equipment will continue to operate in their established fields.

Two contracts have already been received by the new partnership. One is for data link equipment for a secret radar installation, and the other for recording equipment for experiments in the detection of underground nuclear explosions.

AT the exhibition organised in conjunction with the Institute of Fuel's Conference on Waste-Heat Recovery from Industrial Furnaces—Bournemouth, 15th to 19th May—**George Kent Ltd.** will be displaying examples from their current range of products designed to promote greater industrial efficiency.

Electronic instrumentation will include single- and multi-point versions of the Mark 3 Multelec high-speed strip-chart recorder and the Mark 30 single-, two- or three-term air-operated automatic control.

A GENERAL review of the sales and manufacturing activities over the past five years, with particular emphasis on 1960, was the theme of the recent two-day sales conference held by **Square D Ltd.**

The conference was attended by field engineers and area managers of Square D Ltd., members of the headquarters staff directly connected with sales, and the field staff of Square D G.m.b.H., the German subsidiary.

In a preview of the company's new range of equipment, the field sales force were given the opportunity of seeing the many new products which will be introduced during the coming months.

An address on the company's overall activity and aims was given by Mr. J. L. Thompson, director and general manager.

Mr. S. Paice, export sales manager, presented details of the company's export programme and outlined the plans for intensifying export activity and overseas representation.

A MOBILE demonstration unit of **Marconi Instruments Ltd.** is undertaking a 3,000 mile tour of Northern Germany and Scandinavia. The instruments which will be shown and demonstrated include oscilloscopes, signal generators, valve voltmeters, power meters, bridges, frequency measuring apparatus and pH and moisture meters.

A NEW electronics factory to be opened in Inverigo, Northern Italy, will be operated by a company to be called **Pye Electronic S.p.A.,** with offices in Milan. Managing director of the new company is Mr. L. W. Jones, M.I.P.E., works director of the Pye Group of Companies.

Selling, distribution and service arrangements will be under Dr. Giulio Falcinelli, until recently managing director of l'Admiral Italiana S.p.A. Technical manager will be Mr. C. K. Jones, previously with the I.N.F.I.N. group in Rome.

The Italian Pye factory, which is now in production, has a site area of approximately 150,000 sq ft. It is expected that it will become Pye's Common Market factory and will supply or manufacture television, radio, domestic appliances and electronic equipment.

Other members of the board of Pye Electronic S.p.A. are Mr. L. G. Hawkins (President), Mr. J. O. Stanley, Mr. Victor Ercolani and Signor Freddie Barda.

A GILT medal and certificate have been awarded to **John Bass Ltd.** for the invention of a watch assembly cabinet, designed specifically for assembling intricate watch mechanisms in absolutely dust-free conditions.

This is a development of the "Bassaire" pressurised assembly P/B Model, awarded a gold medal in 1958.

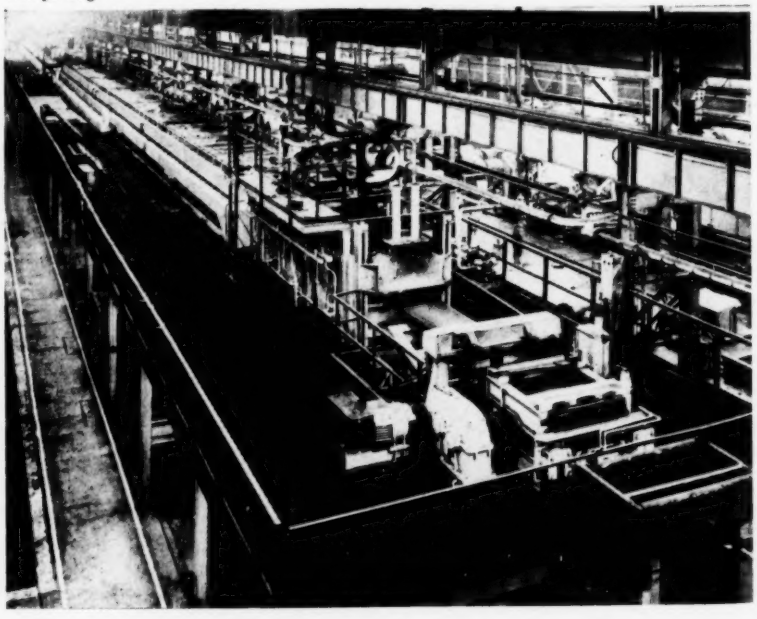
Air is drawn into the back of the watch assembly cabinet, filtered, then the supply is split. Part of it flows across the work area, maintaining a constant pressure. The other part of the air is ducted and comes up through a grille in the base. The air curtain thus formed in front of the cabinet effectively prevents any back-flow of air.

This cabinet is eminently suitable for handling extremely small light parts for work under absolutely clean conditions, since the air is filtered down to better than two microns.

Fairchild Camera en Instrumenten Mij N.V. of Amsterdam announce the appointment of R. J. Bloomfield as international publicity and public relations manager for both the Dutch organisation and their associated British company, Fairchild Camera and Instrument (U.K.) Ltd.

Mr. Bloomfield will operate from the London office at Grove House, 551 London Road, Isleworth, Middlesex (Phone: Isleworth 5941), with direct responsibility to Mr. Chandler J. Abbott, a director of both the British and Dutch companies and overseas manager of the American parent company.

G.E.C. 2000 kW continuous-strip inter-annealing furnace, viewed from the entry end. It is installed in the Cookley Works of Richard Thomas and Baldwins Ltd., and is over 350 ft long



The position involves the organisation of all advertising, general publicity and public relations work outside the United States and Canada for the Fairchild range of Scan-a-graver and Scan-a-sizer electronic engraving machines, Ascorlux xenon arc equipment, and other Fairchild products for the graphic arts.

A CONTRACT to build a new factory, on a 20 acre site at Hednesford, Staffs., has been approved in principle between Mr. S. M. Cooper, chairman and managing director of **Fafnir Bearing Co. Ltd.,** and Mr. H. S. Booth, managing director of Shepley Booth & Associates Ltd., civil engineers and building specialists, of Granville House, Tettenhall Road, Wolverhampton.

This new building, which will initially cover a total of 60,000 square feet, is to re-house the Hednesford workers with the most modern type of factory building, and products manufactured there will be exported to all parts of the world.

Two new factory buildings of 20,000 sq ft have been acquired by **Adrema, Ltd.,** on the Bilton Estate, Portsmouth.

THE **Honeywell Controls Ltd.** factory at Newhouse Industrial Estate, Motherwell, Lanarkshire, will be closed from mid-day, 14th July to 31st July, 1961. The Hemel Hempstead plant will close from 11th August to 28th August.

Sales and service of Honeywell products will still be available as usual from the 10 Branch Offices in the U.K. and a small administrative staff will be available at the factories.

G. A. Platon Ltd. have now moved to 281 Davidson Road, Croydon, Surrey. Their range of Flostat flow controllers for liquids and gases has been extended and now includes miniature models for analytical work and burner control.

British Driver-Harris Co. Ltd. announce that their offices in Birmingham at 55 George Street, Parade, Birmingham, 3, have moved to:

Target Works,
Hancock Road,
Birmingham, 8.
Telephone: EAST 3761.

AGREEMENTS

ARRANGEMENTS have been made whereby the servicing of **English Electric** radio-frequency induction heaters will be taken over by **Delapena & Son Limited,** Cheltenham, as from 1st June, 1961. This follows the cessation by English Electric of activity in the r.f. heating field.

Continuity of servicing, maintenance and supply of spare parts to all present users of English Electric induction heating equipment is assured by this arrangement with Delapena. Delapena & Son Ltd. already have a Service Department whose sole concern is the installation and maintenance of induction heating equipment; this department is being considerably expanded to cope with the additional work and Delapena service engineers are being given courses of instruction in the maintenance of English Electric equipment. Adequate stocks of spares will be made available to Delapena & Son Ltd. by the English Electric Company Limited and from 1st June will be obtainable from Delapena's Service Department. Until this date spares will continue to be held at The English Electric Company's Kidsgrove Works.

BY a newly completed agreement, **British Insulated Callender's Cables Ltd.** will act as distributors to the electrical industry in Great Britain and Northern Ireland of fibre-reinforced resin materials manufactured by **Thermotank Plastic Engineering Ltd.,** Chapelhall, Lanarkshire.

THE **Plessey Co. Ltd.** announces that a licence agreement has been concluded with **Rini International,** whereby Plessey will manufacture Rini thermal overload protectors and starting relays, with exclusive marketing rights in the U.K. and non-exclusive rights elsewhere, except Italy.

Elettrotecnica Rini S.p.A., of Milan, is one of the leading manufacturers of protectors and relays in Europe, and the comprehensive range includes patented relay-protectors which combine the features of overload protection and relay control in a single unit.

Expert Industrial Controls Ltd., Ashby-de-la-Zouch, and **R. B. Denison Manufacturing Co.,** Bedford, Ohio, U.S.A., have signed an agreement whereby Expert Industrial Controls manufacture the complete range of Denison Loxswitches in the United Kingdom.

The Denison Loxswitch will now be available in this country for the first time and in a comprehensive range of heavy duty and precision limit switches. They cover a wide field of application, including all types of machine tools and handling equipment.

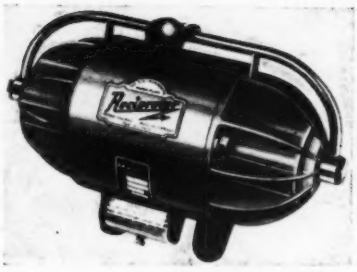
B. & R. Relays Ltd. have been granted the British selling rights for the complete range of CYPAK static switching components manufactured by the French company Le Materiel Electrique S-W.

CYPAK control is based on the fundamental AND, OR, and NOT logic functions. CYPAK logic units contain magnetic circuitry.

All CYPAK units are on the plug-in principle and wiring is by solderless connectors. A minimum of maintenance is needed as there are no contacts to get contaminated and naturally there can be no mechanical wear.

AN agreement has been reached between **Research Control Inc.,** of Tulsa, Oklahoma, and **G. A. Platon Ltd.,** whereby "Minim" valves will become available in this country.

THE transmission equipment selling agreement between **Automatic Telephone & Electric Co. Ltd.** and **Telephone Manufacturing Company** was terminated by mutual consent on 31st March, 1961.



Reciprotor combined vacuum/pressure pump

AGENTS

Edwards High Vacuum Ltd. have been appointed sole United Kingdom and British Commonwealth agents for the new "Reciprotor" combined vacuum/pressure pump manufactured in Denmark.

Operated by an electromagnetic vibrator from an a.c. supply, the pump weighs 10 lb and has a completely oil-free air delivery as no lubrication is necessary.

The "Reciprotor" is available in two versions. The Type 406G is designed for continuous operation and provides a free air displacement of 1·62 ft³/min, a vacuum of 18 in. Hg and a maximum pressure of 7·8 p.s.i. The Type 606G is rated for intermittent operation but has an improved performance, delivering air at 1·77 ft³/min and attaining a vacuum of 22 in. Hg and a maximum pressure of 10·7 p.s.i.

The pump sells at £25 ex works and is available on quick delivery.

Croydon Precision Instrument Co. has been appointed sole U.K. agent for the range of electrical measuring instruments manufactured by NORMA, of Vienna.

As a result of the recent acquisition of Shockley Transistor by the Clevite Corp., of Cleveland, Ohio, **Brush Crystal Co.,** of Hythe, Southampton, an associate of Clevite, have been appointed exclusively to handle the Shockley four-layer diode in the United Kingdom.

Telemechanics Ltd. have recently appointed Messrs. Rualdo Lda., Rua. S. Jose 15-1, Lisbon, 2, as their agents in Portugal.

They have also appointed Magnetic AB as their agents in Sweden. Their address is: Magnetic AB, Stora ny Gatan, Stockholm, 3.

CONTRACTS

Brookhirst Igranic has received an order to supply control equipment for a new factory which has been engineered by W. J. Fraser, of Romford, and which is being erected by South African Titan Products in Umbogintwini.

The factory is scheduled to produce titanium dioxide which forms a basic chemical in the manufacture of paint and paper. The raw material used in making titanium dioxide is ilmenite, of which there are large deposits on the southern coast of Natal.

Brookhirst Igranic's Chester unit is supplying seven Chester Major boards on this contract and the Bedford unit is

responsible for the supply of two 3·3 kW high tension boards. The services controlled are fans, conveyors, elevators, pumps and agitators.

The assembly of these control equipments is being undertaken by Brookhirst Igranic S.A. (Pty) Ltd., of Johannesburg, which is also entrusted with the commissioning of the controls on site.

Firth Cleveland Instruments Ltd. have received a contract from the Ministry of Aviation for the supply of dual channel flowmeter equipment to be fitted in Javelin Mark 8 and Mark 9 aircraft.

The flow transmitters are engine mounted and are capable of indicating the full range of flow from idling to reheat.

THE **Plessey Co Ltd.** announces that an order has been placed by Ferranti for memory systems to equip the first production model of the ATLAS digital computer. This follows the successful operation of Plessey systems in the prototype ATLAS.

EXPORTS

Hilger & Watts report good business done at the Leipzig Spring Fair. It was the first time they had exhibited since 1954. All the industrial control instruments which they took to the Fair were sold, and contracts worth altogether £24,000 were signed whilst they were in Leipzig.

Business with East Germany is expanding all the time, as there is a great demand for mechanical optical instruments to satisfy the needs of the German Democratic Republic's seven-year plan.

Solartron Electronic Group Ltd., of Chessington and Farnborough, Surrey, report good results from their stand at the Leipzig Spring Fair this year.

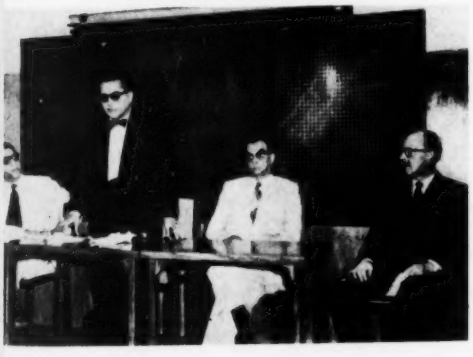
Instruments sold included oscilloscopes worth £10,000 and digital instrumentation, including digital voltmeters worth £3,000. Other orders brought the total sales up to approximately £15,000.

EDUCATION

THE Indian associates of Honeywell Controls Ltd. now have a training school for instrument engineers. H. G. Garrity, training manager of Honeywell Controls Ltd., has just returned from Bombay, after founding the school and conducting its first course.

At the end of the course, he handed the school over to G. S. Krishna Swamy, the training manager appointed by the Indian company. The school will run 6-week courses on industrial instrumentation, for staff and customers.

Inauguration of the Blue Star-Honeywell instrument training school in Bombay. The school was founded recently by H. G. Garrity (extreme right), training manager of Honeywell Controls Ltd.



AT the invitation of the Royal Technical College, Salford, Dr. P. V. Bruel will be flying to this country from Copenhagen in June to lecture at a **two-day post-advanced course on noise measurement and control.**

Dr. Bruel is managing director of the Danish audio and vibration engineers, Bruel and Kjaer, whose electronic instrumentation equipment is used extensively in the United Kingdom. During the course at Salford (2nd and 3rd June), he will be lecturing on microphones.

Another prominent lecturer invited, Mr. John Kuehn (chief audio sales engineer for the London company, B & K Laboratories), will be speaking on the subject of acoustic instrumentation.

OVER seventy digital computer programmers attended a three-day school at **Brighton College of Technology** on 5th, 6th and 7th April. There they met programmers from several European countries, including France, Holland and Denmark, and learnt about and discussed ALGOL 60. The purpose of ALGOL 60 is to express the processes of computation in an international language which can be translated automatically into the particular code of any digital computer whatever its make and individual peculiarities.

The school is organised by the Automatic Programming Information Centre set up by the Department of Mathematics at the beginning of 1960. Membership of the Centre is growing rapidly and now embraces individuals and organisations in France, Sweden, Holland, Italy and the U.S.A. as well as this country.

Tutors included Dr. E. W. Dijkstra, of the Mathematical Centre, Amsterdam, Mr. P. Naur, of the Regnecentralen, Copenhagen, and Mr. M. Woodger, of the National Physical Laboratory.

THE first annual report of the **Electrical and Electronic Manufacturers' Joint Education Board** has just been published.

Throughout the year the board has received reports from representatives of the individual trade associations of the work and publications of their organisations in the educational field. This has ensured that the work of each association was co-ordinated with that being promoted by the rest of the industry.

The board had direct and informal discussions with the chairman and secretary respectively of the National Council for Technological Awards about the proposals for the Diploma of Technology, and expressed their disappointment that the Diploma Courses did not appear to be providing the sort of training that industry required. The representatives from the National Council were able to explain what they planned to achieve.

Other topics discussed in the Annual Report include the problems of sandwich courses, the training of designer draughtsmen and transcribers for electronic circuitry and careers guidance.

AT the annual dinner of the **Witton Engineering Works Apprentices Association,** Mr. T. H. Kelsey, M.A., M.I.E.E., presented various awards. In the Diploma of Technology successes G.E.C. had an amazing achievement. In all the faculties of engineering throughout the country 210 Diplomas of Technology had been awarded, of the 138 awarded in Birmingham, 123 were G.E.C. students.

So far 18 first class honours had been awarded, 12 of them in Birmingham and all 12 to G.E.C. students.

ASSOCIATIONS

A SYSTEM of **technical standardisation** is to be set up throughout Europe, as a result of a recent meeting of Western European national standard organisations, at which it was agreed that the thirteen countries in the Free Trade Association and the European Economic Community should collaborate on an equal footing. It is proposed that the use of internationally agreed characteristics and performance standards from such bodies as I.S.O., I.E.C., C.C.I.T.T., C.C.I.R., and C.E.E. should be developed and promoted.

The U.K. Associations supporting this policy are:

British Radio Equipment Manufacturers' Association

British Radio Valve Manufacturers' Association

Electronic Engineering Association

Electronic, Valve, and Semi-Conductor Manufacturers' Association

Radio and Electronic Components Manufacturers' Federation

Scientific Instrument Manufacturers' Association of G.B.

Telecommunications, Engineering and Manufacturing Association

VISITORS

A PARTY of **14 Russian radio and television engineers,** including three women, visited three of the Pye Group of Companies last week. The visit was designed to show the Russians some of the most advanced electronic equipment produced in Britain.

On arrival they were met by executives of the Pye Group and then taken to the Pye radio and TV factory in St. Andrew's Road where they were shown over the production and assembly lines. They next went to W. G. Pye & Co. Ltd., in York Street, who produce scientific instruments including the argon chromatograph.

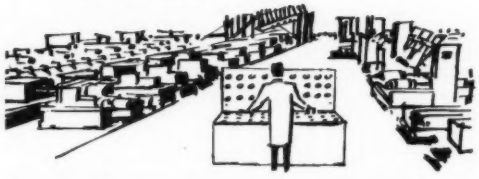
Their tour rounded off with a visit to Pye Telecommunications Ltd., in Newmarket Road, where they saw communications equipment and Pye's new electronic telephone exchange.

The Russian visitors showed a keen interest in everything they saw and were presented with souvenir brochures in-

Electric Motors & Controls-2

Control equipment must enable the motor to be operated effectively, to obtain maximum productive efficiency of a given machine. An outstanding advantage of individual electric drives is the flexibility of control available. Control equipment may be manual, semi-automatic or fully automatic, and includes gear for the following operations:

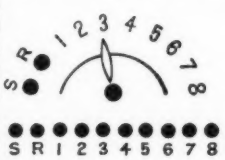
(a) Starting
(b) Speed Control (this subject will be dealt with in Data Sheet No. 16)
(c) Reversing
(d) Stopping
(e) Switching off automatically if operating conditions become abnormal
(f) Isolation of motor and control equipment from the supply.



Every application of power has its own particular control requirements—and they are legion. Below are featured four uses of electric motors and their controls; they are given only as examples and represent but a small fraction of the whole picture.

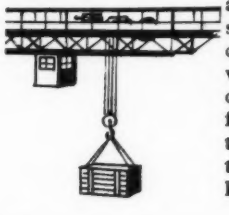
Turret-lathe Control

Various speeds are required for different tools, and it is possible to arrange, for instance, for a four-speed headstock, forward and reverse, incorporating a power-operated pre-selector speed change. By using a two-speed double-wound motor, eight speeds forward or reverse are obtainable. A dial on the headstock is set to the required speed and when a knob in the centre of the dial is pressed, the power-operated mechanism changes the speed instantly.



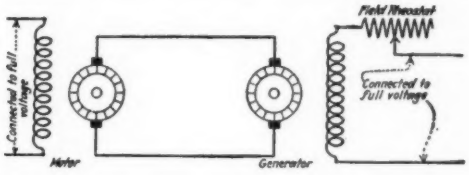
Crane Control

This is a form of control which must be flexible yet completely foolproof. It is, for instance, possible to arrange for motor switching to be performed by contactors in response to movement of the crane driver's master controller which has a number of notches, each of which is associated with a particular set of contactors for acceleration, speed control, reversing and braking. If the controller is moved quickly from the 'off' position to the 'last point lowering', the rate of acceleration is limited automatically by the relays. These also govern the retardation in order to prevent a heavy descending load being stopped too suddenly. This is just one of the ways in which electric control mitigates the hazards of crane operation.



Planing-machine Control

Another example of motor control for machine tools is that for planing machines. For general workshop machining, the Ward-Leonard controlled motor, with a speed range of 10 to 1, gives a rapid and smooth reversal of the table travel and is ideally suited for short-stroke work. Two arrangements of Ward-Leonard control are available, the 3-machine set with generator, exciter and driving motor, and a specially designed 4-machine set with an additional auxiliary exciter. With the 3-machine set the control



equipment can include magnetic time relays which automatically adjust a regulator to strengthen the motor field at the instant of reversal and therefore greatly increase the accelerating torque. The auxiliary exciter of the 4-machine set automatically provides 'field forcing' on the generator; in other words, the power input to the motor is increased to give more accelerating torque at the instant of reversal.

Automatic Control

The control equipments described incorporate automatic features which help considerably towards obtaining safe and efficient operation of the driven machine, but much still depends on the human element. Braking equipment, for instance, cannot always become effective until an operative has taken some action. In an emergency this physiological time lag which delays the initial action will also delay the final effect. Fortunately it is often practicable to employ devices, which will be described in other Data Sheets, to 'observe' any abnormal condition and immediately and automatically to initiate the braking system.

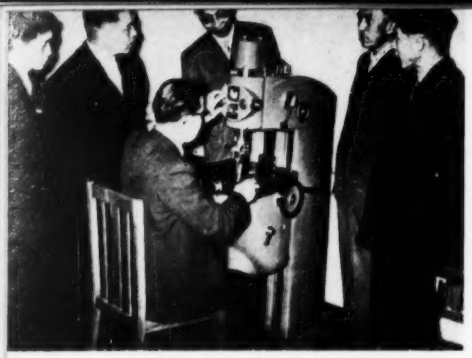
Particular attention should be paid to the positioning of controls. When a machine, or group of machines, requires a large number of push buttons and, in some cases, instruments, etc., the controls can be grouped on a desk with a mimic diagram, located in a position where the operator has full view of the work.

For further information, get in touch with your Electricity Board or write direct to the Electrical Development Association, 2 Savoy Hill, London, W.C.2. TEMple Bar 9434.

They can offer you excellent reference books on electricity and productivity (8/6, or 9/- post free)—'Electric Motors and Controls' is an example.

E.D.A. also have available on free loan within the United Kingdom a series of films on the industrial uses of electricity. Ask for a catalogue.

7918



Members of the Chinese delegation watching a demonstration of the Talyrond Model 50 roundness measuring instrument. Commercial representatives from U.S.S.R., Poland, Rumania, Czechoslovakia and Bulgaria also attended a reception given by Taylor, Taylor and Hobson

cluding pictures of Pye products with captions specially printed in Russian. In the afternoon the party went on a tour of Cambridge.

EXHIBITIONS, CONFERENCES, ETC.

FROM mid-March until mid-June members of the I.E.A. Committee and the organisers, Industrial Exhibitions Ltd., will be touring nine cities, Vienna, Munich, Dusseldorf, Paris, Milan, Brussels, Amsterdam, Stockholm and Frankfurt, telling European manufacturers about the **1962 I.E.A. Exhibition** and encouraging them to show their products or at least visit the exhibition. On the eve of their departure they received a goodwill message from the President of the Board of Trade, the Rt. Hon. Reginald Maudling, M.P.

The Exhibition will be held at Olympia, London, from 28th May to 2nd June, 1962.

THE **Industrial Equipment & Services Exhibition** will be held in Bingley Hall, Birmingham, from the 29th May until 3rd June, inclusive.

During the run of the exhibition a careers exhibition organised by the civic authorities will be running in another part of Bingley Hall.

THE Organisation for European Economic Co-operation—O.E.E.C.—arranged a conference on **"Engineering Education and Industry"** at Baden-Baden, Western Germany, 11th to 13th April. This conference was attended by official delegates from 16 countries. In addition to the official delegates, Eugene H. Rietzke, president, and Arthur F. R. Cotton, managing director for International Operations of the Capitol Radio Engineering Institute (C.R.E.I.), Washington, D.C., were invited as official observers.

C.R.E.I. is an organisation which teaches advanced electronics and nuclear engineering technology, and has a European branch based in London.

Immediately after the conference Mr. Rietzke and Mr. Cotton went to Athens to continue discussions on the establishment of a technical institute there. These discussions were opened at the invitation of the Greek General Staff, who required advice on training personnel in the use and maintenance of electronic defence equipment. There is now a proposal for the establishment of a technical institute by the Greek Government, to be operated by C.R.E.I. and to be used by both civilian and military students.

A **Conference on Engineering Inspection and Non-destructive Testing** will be held in Oxford in September, 1961, to discuss the function of management in relation to inspection, the economics of inspection and non-destructive testing, and the recruitment, education and training of inspection staffs. The conference is being organised jointly by the Institution of Engineering Inspection and the Society of Non-destructive Examination. Residential accommodation at Queen's College and New College, Oxford, has been reserved over the period 5th to 8th September, 1961. The total cost including conference fee, accommodation and all meals in College will be £9 10s. per delegate.

Further information may be obtained from the Oxford Conference Secretariat, The Institution of Engineering Inspection, 616 Grand Buildings, Trafalgar Square, London, W.C.2.

RESEARCH

SCIENTISTS of U.S. General Electric are testing a thermionic conversion device that may greatly increase the overall efficiency of nuclear power stations.

The device, called a **plasma diode,** is a high-temperature thermionic converter using caesium gas and a uranium-bearing cathode. These diodes could be built into nuclear fuel elements, where the fissioning of the uranium in the cathode would provide the high temperatures in the range of 4,500°F needed for efficient direct conversion. An electrical lead from the fuel element would draw off the electricity. Heat rejected by the device would be converted into electricity by the standard thermodynamic cycle.

Developmental diodes are now being made at GE's Vallecitos Atomic Laboratory. Single-cell devices able to generate several watts are now undergoing tests in a special fuel capsule in the test reactor there.

Although thermionic conversion devices capable of producing approximately 20 watts per square centimetre of cathode area have been demonstrated, much more development will be necessary before they will be suitable for general application. However, recent design advances by Vallecitos project scientists indicate that they can have an advanced plasma diode ready to be tested in a prototype nuclear power plant within five years.

GE do not feel that plasma diodes can be used in conventional power plants because their operating temperatures are too low.

A NEW device for **converting electrical energy into ultrasonic energy** and vice versa at microwave frequencies was described by D. L. White, of Bell Telephone Laboratories, at a session of the Institute of Radio Engineers International Convention in New York City. The new device is a piezo-electric transducer utilising a semiconductor depletion layer. It is expected to be employed primarily in ultrasonic delay lines where its operation at high frequencies and wide bandwidth will make it possible to store large amounts of information.

Another possible use will be as a tool for studying the acoustical properties of materials at higher ultrasonic frequencies. It is anticipated that large amplitude ultrasonic waves can be generated in materials at microwave frequencies and also extremely weak waves can be detected with greater efficiency than with existing transducers.

The transducer consists of a plate of piezo-electric semiconductor (such as gallium arsenide) on which a thin metal film is deposited. The film constitutes a non-ohmic rectifying contact which causes a depletion layer to form. (A depletion layer is a thin region of high resistivity that forms at the interface of two dissimilar materials such as a p-n junction in a semiconductor or a rectifying metal-to-semiconductor contact. The difference in Fermi levels of the two adjacent materials usually gives rise to an internal electric field which sweeps or "depletes" the thin interface region free of mobile charge carriers, thereby increasing its resistance.) The thickness of the depletion layer can be controlled with a negative bias voltage across the interface.

When an a.c. voltage is applied, most of the voltage drop occurs across the layer and the layer behaves in a manner similar to a very thin piezo-electric crystal which is bonded to a solid. Since the layer is thin, 10^{-3} to 10^{-5} cm, the electric field is very large and considerable piezo-electric stress can be produced in the layer.

The depletion layer transducer has several advantages over an ordinary transducer:

(1) Because the layer is so thin, the greatest efficiency of the transducer is at very high frequencies. Current models operate at under 1,000 Mc/s, but the frequency range is expected to be extended to above 10,000 Mc/s. In this high frequency range, this transducer should be as much as one hundred times more efficient than any other known transducer. With a highly efficient transducer, small electric signals can generate ultrasonic waves and very weak ultrasonic waves can be detected.

(2) The thickness of the layer, hence the resonant frequency of the transducer, can be varied by varying the d.c. bias voltage.

(3) Present models measured at 600 Mc/s have a bandwidth of 5% (30 Mc/s), an order of magnitude larger than typical ceramic transducers, operating at frequencies below 10 Mc/s. This means that a comparable increase should be expected in the amount of information which can be transmitted. It is expected that, with operation at higher frequencies, even wider bandwidths can be achieved.

(4) The transducer is relatively simple to make and easy to handle.

Up to now, the use of ultrasonic delay lines at high frequencies has been limited because ultrasonic waves could not be generated or detected efficiently at microwave frequencies and, furthermore, were considerably attenuated in the delay material. Now, however, the higher efficiency of the depletion layer transducer makes up for these losses and makes possible delay lines having longer delay times.

In experiments at Bell Laboratories, the new depletion layer transducers operated well at frequencies as high as 830 Mc/s.

BRITISH TRADE FAIR MOSCOW

Associated Electrical Industries Ltd.

THE AEI stand is one of the largest and is dominated by a 20 ft long mural by Abram Games which symbolises the products which electrify this modern world.

The AEI MS7 mass spectrometer will be of special interest to the Russians who have recently ordered two for use in nuclear research. One of these will be in use on the stand. The Instrumentation Division of AEI is also displaying vacuum pumps and Pirani gauges.

Among the models of turbines and power equipment being shown by the Turbine-Generator Division of AEI is one of a 500 kW mobile power station which will recall wartime collaboration with Russia. At a time when the U.S.S.R. was faced with immense problems of reconstruction thirty-five such stations, ranging from 1,000 kW to 5,000 kW and with a total output of 101,000 kW, were made by AEI and sent by the Ministry of Supply under the Aid Scheme. They had originally been designed when there was a possibility of Britain's own power installations being seriously damaged, but eventually were redesigned for use on Russian railway systems.

In addition to a range of solid models of turbines, the same Division will show a sectioned model of the 300 megawatt turbine generator now being built for the West Thurrock Power Station and also of an oilfield power station, where a gas turbine generator (type L51C) is now being installed.

A working model of an on-load tap changer mounted on a single-phase transformer has been made by AEI's Transformer Division. The on-load tap changer is of the fully insulated resistor-transition type which AEI has been making for twenty-eight years. This particular type can be for voltages up to 300 kV and currents up to 1,800 amp.

Traction Division will have models of three of their locomotives.

Models of the P. & O.'s *Canberra* and of De Havilland's latest jet air liner, the Trident, will be on the stand as examples of modern developments in which AEI plays an important part.

Among a wide variety of cables which will be seen is a sectioned sample of the Cross-Channel cable which is being laid to link the power systems of England and France. AEI Cable Division and British Callenders Cables Ltd. are jointly manufacturing the British half of this link which will enable 160 megawatts of power to be exchanged.

A special display will be made of the AEI true motion Escort marine radar.

The research section includes a display of semiconductors with a silicon carbide rectifier operating in a high temperature furnace; a model of the " Merlin " reactor; nuclear metals; and metal cutting demonstrations.

Among the seven members of the staff fluent in Russian who will be on duty are three engineers. Mr. R. H. Veysey, who speaks Russian, will be in charge of the stand, which was designed by Jack Howe & Partners.

Dunford & Elliott Engineering Group

THE Dunford & Elliott Engineering Group will be exhibiting a selection of products manufactured by their member companies.

The chief and largest exhibit will be a rotary louvre packaged drying unit fabricated in stainless steel, using steam as the heating medium and capable of evaporating 400 lb of water per hour. This unit will be operating on a closed circuit, handling polyester. Adjacent to the packaged unit will be an animator showing the internal operation of this machine and how it handles the polyester.

Among other exhibits will be :

1. A typical Lindars simulated automation of a complete process eliminating manual operation, shown on a panel.
2. Pre-set metering control equipment for the control of fluids over any given number of outlets, with punch card control and digital readout.
3. An Elliott-Automa high speed electronic checkweigher and handling system for check-weighing packaged goods at the rate of 150 per minute with 0·2% accuracy. This item has been specifically requested by the Russians.
4. A Loma electronic metal detector employing transistors and printed circuits for detecting small particles of metal in non-conducting materials such as foods, plastics, chemicals, wood, etc.

Morgan Crucible Group

THE Morgan Crucible Group, makers of carbon electrical and engineering parts, radio and electronic components, refractories, crucibles and crucible furnaces, will be exhibiting a range of their products. The Group will be represented by a new subsidiary company—Morganite Exports Ltd. The three main exhibits displayed will be " Purox " refractories, " Crusilite " heating elements, " Morganite " and " Morganohm " resistors.

SIMA Exhibit

NINETEEN member firms of SIMA, will exhibit 500 instruments worth £220,000 and ranging from £1 4s. 1d. to £34,600 in individual value on the joint SIMA stand at the British Trade Fair, Moscow, 19th May to 4th June.

A wide range of signal generators, stabilised power supplies and constant voltage transformers will be exhibited by Advance Components Ltd.

The Avo Ltd. stand will have many of their well-known measuring instruments and accessories for laboratory and production testing, including the AVO Model 8X, constructed for use under conditions of extreme low and high temperatures and panclimatic humidity, a Mk. IV valve characteristic meter, battery operated transistor analyser, and a Douglas electrically programmed coil winding machine.

The Cambridge Instrument Co. Ltd. group of instruments covers quick acting electronic recorders, potentiometers, a pocket pH meter, water analysis equipment, multirange control units, a wide variety of Cambridge pH electrode systems and conductivity electrodes for other purposes, indicators, thermocouples and a hydrogen in steel measuring outfit.

Several unique oscillographs are shown by Cossor Instruments Ltd., a fast rise time square wave generator, a millimicrosecond pulse generator, oscillograph camera, amplifiers and other accessories.

Noise or sound measurement in most of its aspects is the speciality of Dawe Instruments, Ltd., together with a portable, battery-operated transistor stroboscope, transistor phase meter, vibration meter and an automatic low frequency sweep oscillator.

Electronic Instruments Ltd. will show a range of pH meters and also the Vibron. An automatic titration method of analysis developed by E.I.L. is shown on the stand of the Distillers Co. Ltd.

Stroboscopes, contamination monitors, industrial television, closed circuit colour television and cameras are among the demonstrations by E.M.I. Electronics Ltd.

The £34,500 general purpose digital computer is demonstrated by Elliott Brothers (London) Ltd., together with printers, accessories for slow speed control logics and other applications.

Testing sieves of guaranteed aperture sizes and a test sieve shaker are shown by Endecotts (Filters) Ltd.

A radioactive dust sampler, pulse generators, radiation and air pollution monitors and automatic equipment for the inspection of impact extrusion slugs are the concern of Fleming Radio (Developments) Ltd.

Specialists in the field, Goodmans Industries Ltd. exhibit vibration generators from 2 lb thrust (1 kilo) to 1,750 lb (800 kilos) thrust and associated equipment.

Chromatographic analysis apparatus, moisture and density meters based on radioisotopes, and a flame ionisation unit are among the many interesting research laboratory instruments shown by Griffin & George (Sales) Ltd.

The Courtney-Pratt 150,000 exposures per second camera, with the records available 10 minutes after exposure, 35 mm oscilloscope cameras, transducers for many physical measurements and dynamometers are among the instruments of J. Langham Thompson, Ltd.

A hand and clothing radioactive contamination monitor, a nuclear magnetic spectrometer, an electronically controlled machine for marking out and drilling sheet metal, an ultrasonic drill for brittle materials, ultrasonic surgical cleaners, oscilloscopes, magnetic storage matrices, medical X-ray accessories and a very wide range of Geiger Müller radiation tubes will be exhibited by Mullard Equipment Ltd.

Speedy, highly accurate equipments for the measurement of molten metal temperatures such as steel, both in the laboratory and production, at one end of the scale and hypodermic needle thermocouples for probing soft materials such as the human body, rubber, etc., are shown by Negretti & Zambra Ltd. Also included are various types of pneumatic temperature transmitters, which will measure differences of a fraction of a degree, thickness detectors and their world-renowned meteorological instruments.

Circle **371** for further information

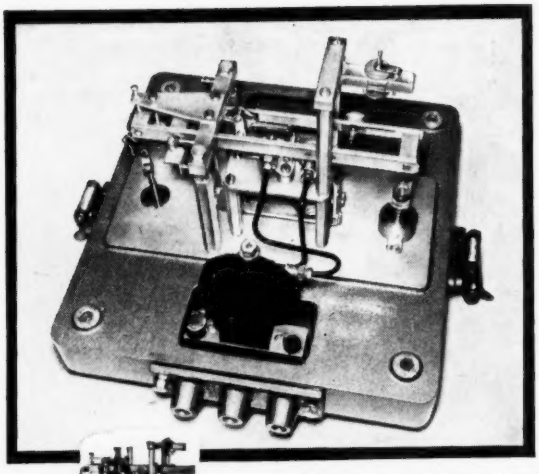
MORE ACCURATE DENSITY MEASUREMENT

— new design of RM Density Meter gives improved sensitivity and offers temperature compensation.

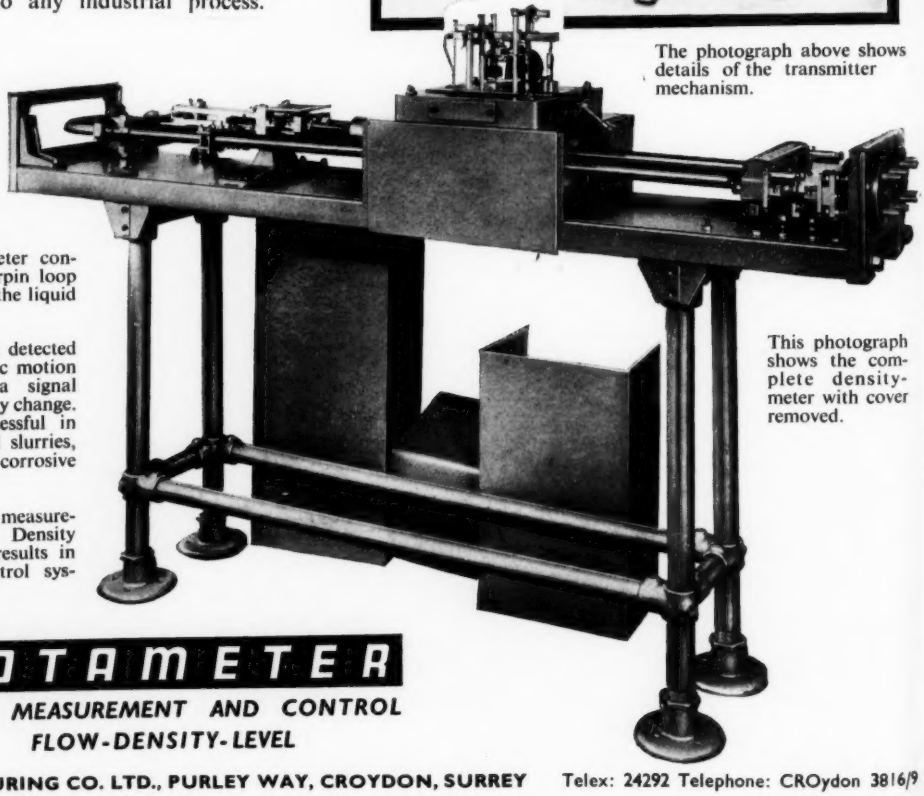
This new design, the Mk. 3 R.M. Density Meter, embodies many improvements including the following:

* Maximum sensitivity 0·025 gm/ml density change full scale.
* Compensation for change in process temperature as an option.
* Total enclosure protects against unauthorised adjustment and dirty atmospheres.
* Easy access to all adjustments.
* Choice of pipe size: 1″, 1¼″ or 1½″ bore.
* Redesigned transmitter eliminates massive damping and saves space.

We shall be pleased to give furthur information, or to advise on the application of the R.M. Density Meter to any industrial process.



The photograph above shows details of the transmitter mechanism.



This photograph shows the complete density-meter with cover removed.

The R.M. Density Meter continuously weighs a hairpin loop of pipe through which the liquid or slurry is fed

Changes in density are detected by pneumatic or electric motion balance to provide a signal linearly related to density change. It is particularly successful in dealing with muds and slurries, and will handle most corrosive liquids if required.

On account of its small measurement lag the R.M. Density Meter gives excellent results in automatic density control systems.

ROTAMETER

FLUID MEASUREMENT AND CONTROL

FLOW-DENSITY-LEVEL

ROTAMETER MANUFACTURING CO. LTD., PURLEY WAY, CROYDON, SURREY Telex: 24292 Telephone: CROydon 3816/9

D42/524

The Solartron Electronic Group Ltd. show among a wide range the new, miniature double beam oscilloscope. Other instruments include a direct reading capacitance bridge, clip-on d.c. milliameter, many types of oscillators, amplifiers, dynamic analysis test equipment, digital voltmeters, an analogue digital converter, pressure transducers, a process response analyser and an X-ray fluorescent spectrometer.

Telequipment Ltd. show a range of low-priced oscilloscopes known as "Servi-scopes", together with a 100× gain pre-amplifier and oscillograph recording camera with motor attachment.

The SARAH search, rescue and homing equipment for the accurate location of crashed aircraft, crew members, seamen or others lost in the sea or in sparsely populated areas will be shown by Ultra Electronics Ltd. Other equipments include an engine condition analyser, engine vibration indicator, turbine speed and jet pipe temperature control amplifiers.

A universal bridge, a waveform analyser, liquid conductivity sampling cells, liquid dielectric flow-through cell, bridge components, accessories and standards, pulse generators, noise level, vibration, distance meters, electronic micrometer, electronic thermometer, temperature-salinity bridge, a highly accurate digital voltmeter and a v.h.f. portable frequency standard are among the great range of electronic instruments shown by the Wayne Kerr Laboratories Ltd.

In addition to the above a number of other members of the Association, including the Associated Electrical Industries Ltd., Industrial Division, Kelvin & Hughes Ltd., Labgear Ltd., Marconi Instruments Ltd., Optical Measuring Tools Ltd., W. G. Pye Ltd., Rank Precision Industries Ltd., Rank Cintel Ltd., W. Bryan Savage Ltd., Standard Telephones & Cables Ltd., Taylor, Taylor & Hobson, Telcon Metals Ltd., Unicam Instruments Ltd., and W. Watson & Sons Ltd., are showing with their own respective groups of companies in other parts of the Trade Fair.

Telcon Metals Ltd.

THE Telcon Metals organisation produce special metals for a wide range of engineering industries. These are used extensively for electrical instruments, current transformers, telecommunication transformers, recording heads, amplifier components, relays, small motors, magnetic amplifiers and lightweight generators. A range of thermostatic bimetals is also manufactured. These are displayed on the stand, together with a selection of glass-to-metal sealing alloys. Bimetals are employed by the bulk of the domestic appliance manufacturers of Great Britain.

There will also be special displays by Magnetic and Electrical Alloys Ltd., which manufactures nickel iron and silicon iron laminations for small transformers and chokes, and pre-assembled rotors and stators for the motors of domestic appliances. Cold rolled silicon iron cores for transformers and chokes, made by Telcon-Magnetic Cores Ltd., are also featured on the stand. These two companies, together with Toolpro Ltd. (super precision press tools), and Temco Ltd. (stainless steel and electrical resistance alloys), are subsidiary companies of Telcon Metals Limited.

Thomas Bolton and Sons Ltd. and Connollys (Blackley) Ltd., both members of the BICC Group, will be well represented at Moscow on the Telcon Metals stand.

Connollys have been manufacturing enamelled winding wires for some sixty years and claim to be the largest manufacturers of fine enamelled wire in the world.

Their display shows a wide range of such wires in varying insulations in different sizes, such wires having applications for all types of electrical windings used in industrial, commercial and domestic electrical machinery, apparatus and equipment.

The insulated wires exhibited are those insulated with oleo-resinous enamel, vinyl-acetal, polyester, polyurethane, vinyl-acetal nylon combination and a self-bonding product used widely in deflector coils for TV.

Detailed descriptions of these wires are available printed in Russian, and Connollys are hoping to increase their overseas sale of such products. They are already the largest U.K. exporters, their products being available in almost all civilised communities throughout the world.

★ ★ ★

British Standard (B.S.3273 : 1960) For Distant Indicating Thermometers for Ships' Refrigerated Cargo Spaces

WARM tropical seas can upset the workings of refrigerating equipment on board ship, sending up the temperature in the refrigerated cargo spaces. Thermometers connected to these spaces must therefore, be extremely accurate if valuable food cargoes are to arrive in perfect condition after long voyages through the tropics.

This new British Standard, prepared at the request of the Refrigerated Cargo Research Council, lays down requirements and tests to ensure that distant indicating thermometers are robust and that they accurately indicate temperatures from −20°F to +70°F. Further requirements are laid down for thermometers of the electrical resistance type and thermometers of the liquid expansion types. Appendices give information on the calibration of electrical types and the installation and testing on board ship of the thermometers.

Nothing in the standard supersedes the necessity, in appropriate cases, for complying with the requirements of the Classification Societies.

Copies of this standard may be obtained from the British Standards Institution, Sales Branch, 2 Park Street, London, W.1, price 4s. 0d. (Postage will be charged extra to non-subscribers.)

(*Continued from page* 619)

Data Plotting Equipment

The latest addition to Bryans Aeroquipment Ltd.'s range of data plotting equipment is a point plotter. It can be used to plot points of a graph from tabulated data, when used in conjunction with their X and Y co-ordinate plotting table. Alternatively it can be used as a decade d.c. voltage generator.

Circle **70** *for further details.*

Revised Price Lists

International Rectifier Co. (Great Britain) Ltd. have revised the prices of their medium power diodes, high voltage cartridges, medium power silicon stacks and high power diodes, making certain reductions in price.

Circle **71** *for further details.*

Mercury Cleaner

A mercury cleaner which can handle 2 to 3 lb of mercury per minute is described in leaflet CMP/1 from Loughborough Glass Co. Ltd.

Circle **72** *for further details.*

Coaxial Relays

List No. 167/C from Londex Ltd. gives specifications of six types of coaxial relay together with the latest Ministry reference numbers.

Circle **73** *for further details.*

Counters

List No. 172/C describes the electronic counters and batch counters available from Londex Ltd. Details are given of construction, application and count display.

Circle **74** *for further details.*

Silicon Power Diodes

Bulletin 2009 from the International Rectifier Co. (Great Britain) Ltd. describes the company's range of 100 to 600 p.i.v. silicon power diodes. Graphs are given of the absolute maximum rectified d.c. output current vs ambient temperature, typical reverse leakage at rated p.i.v. intermittent overload and typical forward characteristics.

Circle **75** *for further details.*

Dallmeyer Lenses

A complete catalogue of the lenses manufactured by J. H. Dallmeyer Ltd. is now available. Additional catalogues covering enlarging lenses, wide angle lenses, and lenses for industrial, scientific, medical and professional photography are also available.

Circle **76** *for further details.*

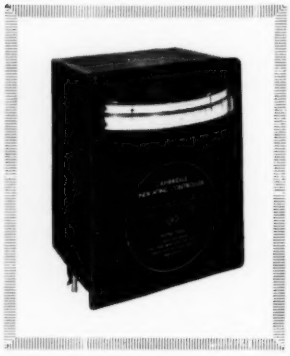
Torque Motors

De Havilland electromechanical torque motors for driving control valves of hydraulic and pneumatic servo actuators, governor throttle valves of air turbines, and for many recording instruments are described in Pamphlet 5110. Performance curves are also given.

Circle **77** *for further details.*

(*Continued on page* 639)

Circle 372 for further information



all right....

FOR WATER PURITY OR ACID STRENGTH

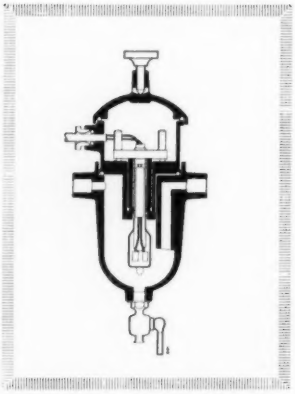
The Cambridge industrial conductivity measuring system is equally successful for determining water purity and acid strength. In the purity measuring types the whole system is fully enclosed so that the risks of contamination and consequent false readings are negligible. The equipment is supplied complete.

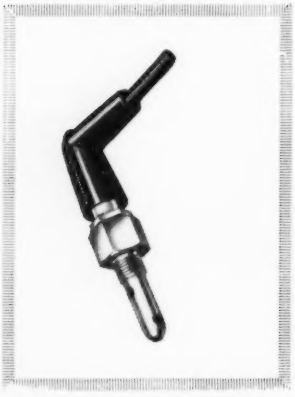
APPLICATIONS

BOILER FEED WATER. Purity of boiler feed water is vital. In modern boilers feed water is forced at high pressure. For these applications the Cambridge high pressure measuring and reference cells, of new design and only 4 inches long, are screwed into the process pipe line, or tank, and will operate under pressure up to 2,000 p.s.i.

TURBINE CONDENSATE. Where turbine condensate is used for processing, its purity can be checked by the Cambridge continuous flow electrode system which includes a reference electrode, giving automatic temperature compensation. Similarly, the production of distilled water from process steam can be monitored with the same equipment.

SULPHURIC ACID MANUFACTURE. A high sensitivity of measurement is achieved e.g. 97—99% H_2SO_4. Other applications, such as the treatment of industrial effluents and plant wastes can also be effected.





INDICATORS, RECORDERS, ALARMS, CONTROLLERS

The illustrations above show (top) the Cambridge Electronic Recorder, which can be supplied for multipoint applications (up to 12) and also as a recording controller (or alarm); (left) the Cambridge Model 'B' Recorder (for 1 or 2 points) with 25-hour chart useful for batch processes; (right) the Cambridge indicating controller often used as an alarm indicator.

ELECTRODES These are illustrated left: (top) the Cambridge continuous flow electrode system, and (bottom) the Cambridge high pressure measuring cell.

Write for list 31Y. For future publications, ask for Mailing Form Y/5/61.

Cambridge INDUSTRIAL CONDUCTIVITY APPARATUS

CAMBRIDGE INSTRUMENT CO. LTD., 13 GROSVENOR PLACE, LONDON, S.W.1

Mr. W. A. C. Maskell

Dr. A. C. Robb

Mr. D. G. Johnson

Mr. R. E. Leete

PERSONALITIES

Mr. W. A. C. Maskell, B.Sc. (Eng.), M.I.E.E., F.B.I.M., Sen.M.I.R.E., general manager of The General Electric Co. Ltd.'s Telecommunication Group at Coventry since October, 1959, has been appointed managing director of the Group.

Belling & Lee Ltd. have appointed **Dr. A. C. Robb, M.Eng., Ph.D., A.M.I.E.E.,** as technical manager.

Dr. Robb graduated at Liverpool University, and obtained a Master's Degree for post-graduate work. Subsequently he was awarded a Research Fellowship at Glasgow University to work on the design and commissioning of high voltage particle accelerators, and gained his Ph.D. for related studies. He has had considerable industrial experience in technical management in the fields of light engineering and instrumentation.

B & K Laboratories Ltd. have appointed **Mr. Ronald E. Walford** as installation engineer for their Vibration Systems Division.

They have appointed **Mr. Hugh Murphy** as their new shipping manager.

Formerly with shipping agents Wingate and Johnson Ltd., for whom he handled all American traffic, Mr. Murphy will be based at the Union Street (London) offices of his new company.

Stanhope Seta Ltd. have appointed **George Sell, F.Inst.Pet.,** technical publicity manager.

H. J. Beach, sales manager for B. & R. Relays Ltd., has been paying a flying visit to the Continent. He visited the Utrecht Fair, but the primary object of his visit was to gain first hand impressions of the relay market in Benelux. He was working in conjunction with Groenpol, B. & R.'s Benelux agents, whose head office is based on Amsterdam.

Mr. Anthony M. Browne, B.Sc., A.R.C.Sc.I., has been elected president of the British Electrical and Allied Manufacturers' Association and **Mr. H. H. Mullens, B.Sc., M.I.E.E.,** has been elected deputy president.

Mr. Browne is chairman and managing director of Hackbridge and Hewittic Electric Co. Ltd. and chairman of Combined Electrical Manufacturers Ltd. He has been a member of the BEAMA Council since 1954 and is a member of the BEAMA Export Panel and of the recently formed Export Council of Europe.

Mr. Mullens is chairman and managing director of A. Reyrolle & Co. Ltd. and chairman of C. A. Parsons & Co. Ltd. He was chairman of the North Eastern Electricity Board, 1948-54, and a member of the British Electricity Authority, 1952-53.

Michael J. Pleeth has been appointed marketing manager of Brush Crystal Co., of Hythe, Southampton, and took up his new duties on 4th April.

Mr. H. H. Woolveridge, B.Sc. (a director of The Distillers Co. Ltd.), has been elected president of the British Plastics Federation in succession to Mr. C. H. Glassey.

The appointment of **Mr. K. Woodard** as manager of IBM Service Bureaux and Data Processing Centres in the United Kingdom has been announced by IBM United Kingdom Ltd.

Mr. Woodard has been connected with punched card accounting since leaving the Navy in 1946, both in the Head Office of a leading oil company and in Abadan. He joined IBM in 1952 and worked as a salesman of data processing equipment in London and other districts. For the past four years he has been manager of the Newcastle branch of the company.

The new manager of the Newcastle branch is **Mr. John Evered.**

Mr. H. de Grey-Warter, O.B.E., T.D., M.I.P.R., has joined Alenco Ltd. as group advertising and publicity manager. The Alenco group consists of the British Ermeto Corp. Ltd., Simplifix Couplings Ltd., Kay & Co. (Engineers) Ltd., S. S. Stott Ltd., and the Kent Nail Works Ltd.

Mr. D. G. Johnson, formerly contracts manager of Smiths Aircraft Instruments Ltd., has been appointed chief technical sales executive of Smiths Aviation Division and is now responsible for all sales and contract matters.

Mr. R. E. Leete, A.F.R.Ae.S., formerly contracts and sales manager of The Sperry Gyroscope Co. Ltd., has been appointed contracts manager of Smiths Aviation Division. He succeeds Mr. D. G. Johnson, whose promotion to chief technical sales executive was announced in March, and he will be based at the Division's administration headquarters at Kelvin House, Wembley Park, Middlesex.

Mr. Geoffrey Gouriet, technical director of The Wayne Kerr Laboratories Ltd., and **Mr. Gordon Ball,** general sales manager, are making a five-week tour of the U.S.A.

After attending the I.R.E. Show, where the Wayne Kerr transfer function computer SA100 will be shown for the first time in America, Mr. Gouriet and Mr. Ball will lecture on and demonstrate the computer in various parts of the country.

Mr. William Reid has retired from executive duties with The Distillers Company Ltd., and has been succeeded as chairman of the management committee by **Mr. T. F. A. Board. Mr. H. H. Woolveridge** has been appointed as a member of the management committee.

Mr. Reid has resigned also from a number of other offices and the following appointments have been made:

Mr. P. H. Hogg to be chairman of John Haig & Co. Ltd.

Mr. W. D. Burnet to be chairman of Scottish Malt Distillers Ltd.

Mr. W. H. Greaves to be chairman of Tanqueray Gordon & Co. Ltd.

Mr. Greaves will be succeeded by Mr. G. McNeil as managing director of Tanqueray Gordon & Co. Ltd.

Mr. E. G. Gross, a director of the company, has been appointed as resident director in charge of all the company's interests in Australia.

Mr. F. R. Allen, an executive director of Firth Cleveland Instruments Ltd., is now in charge of the company's Sales Engineering Department.

Mr. W. J. Megson, a specialist in industrial recorders, has joined Firth Cleveland Instruments Ltd.,as instrument representative for the North East area of England (Northumberland, Durham and Yorkshire).

On being elected to the board of Lang Pneumatic, and appointed general manager, **Mr. G. E. Jowitt** retired from position as secretary with effect from the 1st April. **Mr. G. H. Oxborrow,** from a well-known London firm of chartered accountants, will take over the position as secretary from that date.

Mr. John Brown, managing director of Aveley Electric Ltd., has been making a fourteen day business trip to Canada and America.

The prime object of the trip was to investigate the market for a number of toroidal products the company is now introducing, d.c.-d.c. converters, a.c.-d.c. inverters and audio transformers.

He visited the company's American principals, including Allen B. Du Mont Laboratories, Fairchilds Camera Corp., Stoddart Aircraft Radio Corp. and Dynaco Inc.

Mr. Roy W. Elvidge has been appointed sales manager, Solartron Laboratory Instruments Ltd.

He joined Solartron in September, 1956, as a technical sales engineer, and became a regional manager in 1959.

Mr. D. R. Hall, regional manager, will now be responsible for the London Region.

Mr. R. W. Elvidge

Mrs. A. S. Whiting

Mrs. Ann S. Whiting, B.A., M.I.O.M., has been appointed to the Remington Rand Univac Computer Division, with responsibility for sales promotion, advertising and public relations liaison. Mrs. Whiting has been with Remington for the past three years, engaged in management consultancy work throughout the United Kingdom.

Mr. R. F. G. Hamilton, B.Sc.(Eng.), M.I.E.E., has been appointed manager of the Servo Components Division of Elliott Brothers (London) Ltd. He succeeds Mr. D. Ince, who is taking up new duties within the group in connection with the promotion of exports of aviation equipment.

Mr. Gerard Young, chairman of Tempered Group Ltd., Sheffield, has been visiting New York, Detroit and other cities to appoint distributors for various Group products, including automotive and agricultural springs.

Mr. Young is senior warden of the Cutlers' Company of Hallamshire this year. The Tempered Group Ltd. incorporates the Tempered Spring Co. Ltd., Alfred Beckett & Sons Ltd., Tempered Rubber Components Ltd., and Bergen Tempered Ltd.

The Council of Scientific and Industrial Research has approved the appointment of **Dr. C. J. Jackson, O.B.E., M.Sc.,** as chairman of the Water Pollution Research Board for the period 1st April, 1961, to 31st March, 1966. He succeeds Dr. F. H. Garner, O.B.E., F.R.I.C., M.I.Mech.E., M.I.Chem.E., who completed his term of office on 31st March, 1961.

Dr. Jackson, who is the executive in charge of all water pollution problems for The Distillers Co. Ltd., both on the potable and industrial sides, was a member of the Water Pollution Research Board from 1956-60. He is chairman of the trade effluent panel of the Federation of British Industries.

Mr. E. Etheridge, B.Sc., F.R.I.C., a member of the Central Technical Office of Courtaulds Ltd., has been appointed a member of the Research Board for four years from 1st April, 1961.

Mr. Raymond V. Ely, M.I.E.E., M.I.Mech.E., a specialist in the field of the application of electrical transformers to arc welding and X-ray technology, has been appointed consultant to Gresham Transformers Ltd.

Mr. Ely will advise the company on the needs in the fields of arc welding and X-ray technology, for which Gresham's special advanced designs and manufacturing techniques will be applicable.

Mr. W. R. Owen has been given responsibility for Cardiff and Manchester branches of Honeywell Controls Ltd., in addition to continuing as Birmingham branch manager. This follows the transfer of Mr. T. Jackson and Mr. R. Robson from Manchester and Cardiff respectively to head office positions at Greenford.

Mr. Jackman will now be field sales manager for heating, ventilating and air conditioning controls in commercial buildings. **Mr. Robson** will be market sales manager for the metal processing industries. There are two other new market sales managers: **Mr. E. R. Amery** for the chemical industry and **Mr. H. Wigman** for the food and fibre industries.

W. S. Electronics Ltd. announce the appointment of **Mr. P. Corcoran** as contracts manager.

Mr. Corcoran took up his appointment on the 4th April, 1961, and will be concerned with the exploitation of the company's airborne telecommunications equipment and systems, aircraft telemetry equipment and systems, including acting on behalf of the R.A.E. Aircraft Telemetry Consortium, industrial electronic instrumentation, and Government contracts.

G./Cpt. P. P. W. Sands

W./Cdr. E. W. Anderson

Group Captain P. P. W. Sands, M.B.E., D.F.C., has joined Smiths Aviation Division as personal assistant to the director and general manager, Mr. L. A. Morgan. He will be based at the Division's administration headquarters at Kelvin House, Wembley Park, Middlesex.

Wing-Commander E. W. Anderson, O.B.E., D.F.C., A.F.C., has joined Smiths Aviation Division as specialist adviser on navigational matters to the director of Research and Engineering, Mr. K. Fearnside. He will be based at the Division's research and engineering establishment at Bishops Cleeve, near Cheltenham.

Formerly project manager of the Sperry Gyroscope Company at Bracknell, W/Cdr. Anderson is president of the Institute of Navigation for the current year.

At the Annual General Meeting of the British Compressed Air Society, **Colonel R. W. W. Taylor,** managing director of Lang Pneumatic Ltd., was appointed vice-president of this Society for the ensuing year.

Mr. D. J. Chapman, A.Inst.E., A.M.I.N.E., has been appointed sales manager of Telequipment Ltd. Mr. Chapman joined Telequipment in 1958 as a sales executive after three years with Airmec Limited. He previously served in the Royal Air Force as an instructor at the R.A.F. Air Radio School.

Following the retirement of Mr. G. A. Marriott, who was the first president and chairman of the Electronic Valve and Semi-Conductor Manufacturers' Association (VASCA), **Mr. S. S. Eriks, O.B.E.,** (managing director of Mullard Ltd.) has been elected president and chairman of the council and Mr. C. A. W. Harmer, O.B.E., (a director of Pye Ltd.) has been elected chairman of the Association and chairman of the General Management Committee.

These appointments cover the remainder of the Association's year to 30th June, 1961.

Mr. G. E. Lunt has been appointed a director of John Hill & Sons (Iron Founders) Ltd., of Wolverhampton, a member-company of Staveley Industries Ltd. Mr. Lunt is on the board of the parent company and is managing director of Bradley & Foster Ltd., Darlaston, and its associated companies in the Staveley group.

Mr. W. W. Shaw-Zambra, C.V.O., C.B.E., T.D., retired on March 31st from the post of secretary-general of the Commonwealth Telecommunications Board. He has held this post since the establishment of the Board in 1949, having been secretary of its predecessors, the Imperial Communications Advisory Committee, 1938-44, and the Commonwealth Communications Council, 1944-49. He was joint secretary of the Imperial Communications Committee of the War Cabinet, 1940-44, with the military rank of colonel. He was also secretary of the Commonwealth Telegraphs Conference in Australia, 1942, of the Bermuda Telecommunications Conference, 1945, and of the Commonwealth Telecommunications Conference, 1958.

He is succeeded by **Mr. W. Stubbs, C.B.E., M.C.,** formerly director-general of telecommunications, the Federation of Malaya and the State of Singapore.

Mr. E. A. Elmore has recently been appointed to the board of Gate Machinery Co. Ltd.

Mr. James R. Beard, C.B.E., is to be the next president of the Electrical Research Association.

Mr. Beard is the senior partner in Merz and McLellan, consulting engineers, and is known internationally for his work in the electrical field.

During the month of April, **Dr. H. G. Taylor,** director of the Electrical Research Association, visited New York, Toronto and Montreal.

The primary object of his visit was to attend the Annual Assembly of the International Institute of Welding, held in New York from 11th to 18th April.

In Toronto and Montreal he visited a number of members of the Electrical Research Association and also various prospective members—both manufacturers and supply undertakings.

Two scientists of the Ministry of Aviation's Royal Aircraft Establishment, Farnborough, who are now carrying on advanced research to improve aircraft safety, have been named winners of the 1961 Laura Taber Barbour Air Safety Award. The two Award winners are **Mr. E. S. Calvert** and **Mr. J. W. Sparke,** and they were specifically cited for their "major contribution to world air safety through joint development of the line and bar approach lighting system and the visual glide path indicator now installed and in use at many major airports".

Their line and bar approach lighting system has been installed and currently is being used at some 120 airports, including London Airport, and major civil airports in North America, Britain, Europe, Australia, Asia, the Middle East and the Caribbean region. The North Atlantic Treaty Organisation and the Royal Air Force have also adopted the system.

Solartron have appointed **Mr. T. Morrison** as group field sales manager, U.K. He joined the Solartron organisation in 1954 as a technical sales engineer and has progressively held the post of regional sales manager, Southern England, field sales manager for Solartron Laboratory Instruments Ltd., and sales manager, Solartron Laboratory Instruments Ltd. He was with the original group that went to California in 1956 to set up Solartron Incorporated and was there for six months.

The British Electrical & Allied Manufacturers' Association announce the appointment of **Mr. Robert W. K. Blagbrough** as secretary of the BEAMA Electric Traction Section.

At the first board meeting of CIBA United Kingdom Ltd., held at the company's registered office at 96 Piccadilly, London, W.1, **Mr. J. M. Baldock** agreed to join the board of directors.

Other members of the board of directors of CIBA United Kingdom Limited are:

Chairman: Dr. Dr. h.c. R. Käppeli

Managing Director: Sir Arthur Vere Harvey, O.B.E., M.P.

Swiss: Dr. h.c. A. Wilhelm

Swiss: Dr. A. Brunner
Sir Joseph Napier, Bt., O.B.E.

Mr. A. H. Birch has been appointed manager of the "Westair" Division of Westool Ltd., St. Helen's Auckland, Co. Durham, which produces air conditioning equipment.

He joined the company 10 years ago as chief buyer and has been closely associated with the "Westair" Division since it was formed eight years ago.

SOCIETY OF INSTRUMENT TECHNOLOGY

Bristol Section

A DEPARTURE from normal was made in the December meeting which was held jointly with invited members of the T. & G.W.U. to discuss "Automation: Who Benefits?"

Messrs. A. D. Sellwood and P. E. Stanford represented the T. & G.W.U., in which both are group secretaries, on a panel completed by Mr. E. I. Lowe, of Imperial Smelting Corporation Ltd., and Mr. E. W. R. Little, of Distillers Co., Ltd., both representing the instrumentation viewpoint. Each gave a short introductory talk on the subject of the meeting, after which they proceeded to discuss questions which had been submitted by members of the audience. The discussion was under the chairmanship of Mr. D. M. G. Sneddon, general manager of Imperial Smelting Corporation Ltd.

Questions and answers ranged over a wide field within the terms of reference, from which there emerged general agreement on the inevitability and desirability of automation and the belief of resulting benefit to everyone in industry provided it was properly implemented.

The Section chairman and a member of T. & G.W.U. expressed thanks to the participants for this interesting evening.

At the first 1961 meeting on 19th January, a member of this Section, Mr. P. S. H. Boyce, of The Imperial Tobacco Co. Ltd., lectured on "Some Aspects of Physical Research on Tobacco". It was explained that investigations concerning tobacco are undertaken on a long term basis and involve measurements of characteristics which are sensitive to moisture content. The implications of these considerations formed the background to this paper.

The necessity arises for the measurement of relative humidity in various situations in the work: the several methods employed were described together with their relationship to, and the use of, the reference standard of humidity which has to be maintained.

Provision has also to be made for the supply of air of closely controlled relative humidity and temperature to the experimental environments. Mr. Boyce outlined the essential features and control gear of three air conditioning plants used in this work, and the means of obtaining as close control as possible of the conditions.

"The Application of Marine Instruments" was the title of the lecture by Mr. E. W. Jordan, of Kelvin and Hughes (Marine) Ltd., at the meeting on 14th February.

Instruments encountered in ships are of two main types—the navigational ones such as sextants and chronometers, and, secondly, instruments made necessary by specialised activities of some ships which might require, for example, echo sounders for hydrographic surveying.

Mr. Jordan described in more detail the uses of various instruments in these two categories, and gave particular attention to both radar and echo sounders. Finally a film was shown portraying the life of an apprentice aboard a tanker.

The last ordinary meeting of the present session took place on 13th March. On this occasion Mr. P. A. McKeown, of Société Genevoise Ltd., lectured on "The Industrial Use of Precision Scales" and illustrated his subject by means of a film and slides.

The measurement of length is fundamental to the engineering industries; technical progress and advances in measuring methods are closely related. The lecturer described the various standards of length which have been used and

indicated the superiority of a line standard. In addition the science of interferometry is relevant to the definition of length. Mr. McKeown went on to describe the photo-electric microscope and its relationship to the production and use of precision scales. This instrument is a means of locating accurately the centre of an engraved line on a scale, with very great accuracy. It is applicable to the production of scales, the positioning of carriages, and in a recent application in a line standard comparator which enables a direct comparison of a scale to be made with the wavelength of light.

The film dealt with machines, incorporating standard scales, for highly accurate boring and milling operations.

Chester Section

MEMBERS who attended the lecture on "Satellite Instrumentation", on January 26th, by Dr. R. C. Jennison, of Jodrell Bank, were greatly entertained and instructed by this talk from a man who was obviously a master of his subject.

In a very easy and intimate manner he dealt with the construction and methods of handling the radio telescope and then went on to discuss the technique of instrumenting space probes which were being shot into the atmosphere at Woomera and Cape Canaveral. Reliability and not necessarily miniaturisation was the first and most important factor to ensure that the information being sought from any particular experiment was sent back accurately to the ground.

He demonstrated with actual apparatus that the simplest techniques were often the best, especially in his own particular field of measuring the number and size of micro meteorites.

He touched on similar projects and the way they were being dealt with by his American and Russian colleagues and it was evident that Britain was still well to the front in the development of these new ideas.

It is to be regretted that progress is being held up by the lack of suitably trained technicians.

On Thursday, 24th February, "The Atomic Clock" formed the subject of Mr. J. V. L. Parry. A film on the working of the first caesium clock preceded the lecture. After a brief historical survey of the measurement of time and the need for high degrees of accuracy in astronomy and the variations in the rate of rotation of the earth causing delays of at least 18 months in calculations some standard independent of solar time was needed.

The ammonia clock gave great promise but proved difficult in practice, caesium was finally chosen since it is independent of all parameters except magnetic fields.

The internal construction of the caesium clock was given in some detail and the limiting factors in accuracy pointed out.

A brief description of "Gas Cell" using ammonia vapour ended the lecture. This cell can be made quite small and efforts are being made to produce one suitable for inclusion in space research.

Grangemouth Section

ON the 19th January the Grangemouth Section welcomed Mr. R. Barclay who spoke on "Boiler House Instrumentation."

Mr. R. Barclay considered the stoker fired water tube boiler as it represented the commonest installation in larger industrial plant. He said this type strikes a balance between the simpler shell type boilers on the one hand, and the complex boilers used in major power stations on the other, and by the aid of slides demonstrated the principle of its operation.

The purpose of instruments were discussed, showing how they related to safety, plant protection, and efficiency. Mr. Barclay went on to say instruments are used in the first instance for the safety of personnel, and Ministry of Transport regulations require that every boiler must be fitted with two gauge glasses, and one pressure gauge. Instruments protect the plant by maintaining operating conditions within the limits of the materials used in the boiler and its accessories, also overall efficiency can be computed by measurements taken on each section of the boiler. By operating at near steady state conditions plant wear and tear can be minimised and by the use of automatic boiler control instrumentation greater availability of the boiler could be achieved. The speaker then mentioned points and reasons for selecting various instrument measurements on a boiler, and saying how draught gauges take the guesswork out of supplying the correct amount of combustion air by allowing easy damper setting, indicating leakage of air or gas and sooting up of the various passes. In temperature measurement it was mentioned that, in general, temperatures can be used together with flows to obtain the efficiency of the boiler or any of its units. Temperatures vary with the load but should there be a diminished drop through any section then heating surfaces require attention. Other measurements such as fuel, water and steam were described in detail. Mr. Barclay concluded by discussing flue gas analysis as an aid in achieving maximum combustion efficiency. He stated combustion efficiency calls for the most complete combustion of the fuel in the presence of oxygen. This oxygen is obtained from the combustion air which is a mixture of 20% oxygen and 80% nitrogen by volume. The nitrogen takes no part in the combustion process, and thus obtains heat to no account which produces the major stack loss. So in combustion we are only interested in O_2 and obviously must limit the amount of combustion air so that we do not heat up nitrogen unnecessarily. Correspondingly, if we provide insufficient air, combustion is incomplete and fuel is wasted. There is a theoretical amount of O_2 which is required per unit of fuel but due to the diluting effect of nitrogen in the combustion air, and factors governing the design of combustion apparatus, an amount above the theoretical must be supplied to bring about complete combustion of the fuel. We should therefore be concerned with knowing the smallest amount of excess O_2 which is required to give the best results.

Until comparatively recently there was no available apparatus which would give reliable and continuous analysis of the O_2 content of flue gases, and it was the established practice to measure the carbon dioxide content, and from this infer the excess O_2. The speaker then described, with the aid of sketches, the oxygen instrument which takes advantage of the fact that oxygen is paramagnetic, and showed in many ways the advantages this meter has over the carbon dioxide meter.

A final word was said about boiler feed water and its treatment, and the part played by conductivity and pH measurements.

The paper raised a number of interesting questions, which were ably answered by the speaker and the meeting closed with a vote of thanks proposed by Mr. R. Liveston.

Midland Section

AT the 123rd meeting of the Midland Section held on 10th February, the minutes of the last meeting were read, approved and signed and the secretary, Mr. Smith, then welcomed three new members to the Section and referred to a forthcoming meeting of the I.E.E. on courses, at a technical level, about automatic control.

The chairman then mentioned the forthcoming one-day conference and that, as new committee members would be required soon, nominations should be handed in as soon as possible. He then introduced the speaker of the evening, Mr. R. M. J. Withers, M.A., A.Inst.P., who gave a talk on the application of automatic process control to sugar factories. Mr. Withers commenced his lecture by explaining that the British Sugar Corporation is the only company producing sugar from beet in the U.K. and had worked approximately seven million tons of beet this year, a continually growing quantity. The Corporation has 17 factories in England, plus one in Scotland; the total daily average throughput is about 50,000 tons. The campaign, as it is known, is seasonal so that maintenance and rearranging of plant can be done at leisure during the shut-down period. The introduction of automatic control in recent years has reduced labour usage by 38%, coal usage by 21% and sugar loss by 23% over the last ten years.

Mr. Withers then went on to describe the process of extracting sugar from beet and showed slides of various automatic controls installed to assist in this job ranging from limestone feeder controls to automatic boiler water systems.

The costing of sugar was rather important and Mr. Withers then devoted some time to explaining how the farmers were paid on the sugar content of their load and this was done by weighing the total load of dirty beet, the amount of dirt in a sample of beet and the amount of sugar in the sample of beet. For this latter purpose, an optical saccharimeter was developed using the property of the rotation of polarised light by a magnetic field. This information is fed into an accounting system so that the farmers receive a fair price for their beet. The whole procedure has been agreed with the Board of Trade and the National Farmers' Union, and Mr. Withers then showed a film strip which has been prepared to show all parties concerned the exact method by which the payment is determined.

Mr. Withers then concluded his most

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A clear record of the last two shifts—and the pen already beginning its course on the next chart. In his hand he has the past: on the panel is the present. Arkon Recorders measure gas, air, water and effluent flow, pressure or vacuum, or pressure and vacuum; flows in one inch pipe or 36 inch mains, pressures from 0.1 inches water gauge to 500 lb. per square inch. They give a clear, unmistakable record which you can read like a book, without hesitation and without mistakes. You can leave the chart on for a few hours, a day, or a week—the record will always be there. Easily read, easy to look after, robust enough to stand on the job, Arkon Instruments can help the control of any process—and their accuracy will satisfy even the men in the lab.

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interesting lecture by inviting questions, which he dealt with in a most competent manner. Mr. H. J. Smith then proposed a vote of thanks on behalf of those present.

South Wales Section

THE February meeting of the South Wales Section of the Society of Instrument Technology was held in the Newport and Monmouthshire College of Technology, Newport, on the 22nd February, 1961, Mr. L. J. Mortimer in the chair.

Welcoming members and friends to the Newport meeting the chairman said that the Section was indebted to Principal Harrison for the use of the lecture theatre and the facilities made available were greatly appreciated.

Introducing the speaker, the chairman said that Mr. R. W. Houghton was the manager of the Bellows Division of the Drayton Regulator & Instrument Co., Ltd., and the Section was fortunate in having an expert to talk to them on the manufacture, properties and general uses of metal bellows.

In his opening remarks Mr. Houghton aid that metal bellows were used extensively in all branches of engineering and they played a vital part in the control of temperature in such widely differing applications as a process plant or a domestic refrigerator.

Describing the manufacturing process, the lecturer said that the first step was the production of a tube by deep drawing from flat strip in the case of non-ferrous material and the fabrication by butt or lap welding in the case of stainless steel. The tube would be formed into bellows by one of three different processes:

(1) rolling and spinning
(2) press forming
(3) hydraulic forming

and the bellows discussed in the talk would be hydraulically formed from seamless press drawn tubes. It was evident that only certain materials would be suitable, the essential properties being excellent deep drawing and suitable work hardening properties and resistance to mild corrosion. For most applications brass or phosphor bronze were satisfactory, but where temperature, corrosive or mechanical conditions demanded, stainless steel, monel and other alloys could be used.

The raw material of the bellows manufacturer was flat strip to the order of $\frac{1}{32}$ in. thick. Blanking and cupping was followed by a series of drawing operations, each one reducing the wall thickness and diameter and increasing the length of the cup. It was in this drawing procedure that experience and " know how " played such an important part, the wall thickness of the tube being that of the finished bellows. Each drawing operation work hardened the material and it was necessary to anneal before proceeding. This was carried out in pot, or conveyor furnaces with controlled atmospheres, and was followed by cleaning in a mild acid dip. Throughout the tube manufacturing stage quality and dimensional accuracy was under constant supervision and the final tubes were subjected to careful examination on a statistical quality control basis.

In order to measure the tube wall thickness and to check for constant cross-section throughout the length of the tube a special measuring machine had been designed and built and Mr. Houghton demonstrated the capabilities of this very interesting apparatus. It was in fact an excellent example of non-destructive testing.

A series of well-chosen slides were used by the lecturer to illustrate his remarks and, by means of further slides, he described the hydraulic forming process which involved the unrestricted flowing of the thin wall metal tube under high internal fluid pressure in a collapsible die. The internal pressure causes the metal of the tube to flow transversely between the series of equidistant plates in the die producing the convolutions as the tube collapses, to form the bellows in one continuous operation.

Thus it was evident that the hydraulic process was self-inspecting, the product being proved in the making. Mr. Houghton mentioned the techniques involved in the manufacture of multiply and extra flexible bellows and then turned to the characteristics and properties of metal bellows, explaining that they combined the properties of the helical compression spring and container or envelope which can be hermetically sealed. Bellows should be used in compression, and the load normally associated with bellows in service was usually applied by a gas or vapour. As a spring the bellows would compress or deflect proportionally to the applied load and the spring rate curve for single and multiply bellows was substantially a straight line.

The working life of a bellows depended on the degree of stressing of the material and as a guide to estimating the probable minimum working life of a bellows under various conditions a life prediction chart was shown on the screen. The failure of bellows in service was usually due to mechanical fatigue except of course where attack from a corrosive agent occurred. On very rare occasions stress corrosion and season cracking contributed to failure.

The lecturer discussed the few advantages and many disadvantages of electroplating as a protection from general corrosion. Bellows, like all elastic members, suffered from the normal elastic imperfections of elastic drift and recovery, zero shift and hysteresis. Several methods of reducing these effects were suggested, including the use of a good quality spring acting with the bellows, the spring having a rate higher than the spring rate of the bellows.

Finally, the lecturer dealt with the applications of bellows and said that perhaps their widest use was in thermostatic elements for the direct or remote measurement and control of temperature. Systems operated on one of three different principles and the selection of the filling medium was largely determined by the temperature range involved. The three principles were:

(1) volumetric expansion of an inert gas
(2) pressure generated by a volatile liquid
(3) thermal expansion of a liquid.

The three systems were considered in detail and mention was made of the most suitable applications in each case.

This concluded the lecture and, after a vote of thanks by Mr. V. J. Trenchard, members were invited to examine the excellent display of exhibits and demonstration equipment. This included a large selection of typical bellows and assemblies, tube thickness tester and spring rate measuring machine, and members in groups had the opportunity of discussing with Mr. Houghton and his colleagues the operation of the equipment before the meeting closed.

South Yorkshire Section

MR. W. C. HESELWOOD, an ex-chairman of the South Yorkshire Section, presented an interesting talk to the Section on Wednesday, 4th January, 1961. His subject of " Instruments and Cherry Blossom " referred to a visit made to Japan in March, 1960, primarily to attend an International Conference on Non-destructive Testing.

The flight out by Comet jet took a total time of 26 hours (including stops) and this journey, together with other journeys in Japan, were illustrated most vividly by colour slides.

As an incidental to the conference he was able to visit several steelworks and was greatly impressed by their obvious efficiency and modern plant. Examples were given of the Japanese knowledge and use of transistors with a particularly impressive demonstration of their use in remote control of toy buses.

The talk promoted a great deal of interesting discussion on the way of life and conditions in Japan and it was generally agreed that this type of talk—a mixture of technical discussion and travel—was most instructive.

The fifth meeting of the 1960/61 session of the South Yorkshire Section was held at the Sheffield University on the 16th February, 1961. The chairman, Mr. M. Thomas, introduced Dr. R. H. Baulk, Instrumentation Officer (Samuel Fox & Co. Ltd.) who was to speak on " Some Aspects of Instrumentation in a Steelworks ".

Dr. Baulk commenced his lecture by briefly describing two examples of conventional continuous furnace control. The first example was a two-zone reheat furnace fitted with instruments capable of controlling the ratio of steam, oil- and air-flow on each zone to maintain the furnace at a preset temperature. The second example, a three-zone reheat furnace, utilises the same type of instrumentation as the two-zone furnace, and in addition makes use of a temperature compensated measurement of preheated air.

The lecturer discussed instrumentation used in continental steelworks, expressing the opinion that Swedish instrumentation was generally poor compared with their counterpart in this country. The main trouble seemed to be the lack of service facilities offered by manufacturers.

All-electric controls seem to be favoured by German instrument users although a few hydraulic systems may still be found. The reason for the all-electric control predominance may be found in the fact that most of the German instrument companies have large electrical interests. The practice of mounting instrument

panels on rubber shock mountings is widely adopted and may be used with some advantage in this country. Another useful feature to be seen on the front of the instrument panels are schematic diagrams of the control schemes designed to assist both operator and maintenance staff.

As a pointer to the future of steelworks instrumentation, the speaker described a few instruments that would be of use to a steelworks instrument engineer. An immersion pyrometer was needed which would continuously measure furnace bath temperatures up to 1,900°C. An instrument of this type will find a ready market in the steel industry. With the advent of oxygen blowing of steel, the need has arisen for a pressure compensating oxygen flowmeter fitted with a digital type integrator capable of measuring oxygen flow to an accuracy of better than 1%.

Dr. Baulk went on to describe several special instrument installations which were either working or projected. One interesting installation which has been working for some time is a system of logging and graphing the temperature distribution over the complete area of an electric arc furnace bottom. The system consists of 31 thermocouples distributed at intervals over the furnace bottom. Each couple is scanned by a special electronic multipoint recorder which logs the temperature of each thermocouple. The results are then transferred to a plan of the furnace bottom so as to indicate the temperature contours over the complete furnace bottom area.

When ingots are to be reheated to rolling temperature it is desirable to know as soon as possible the time that rolling temperature will be achieved. A method for predicting this heating time has been statistically proved and it is hoped to implement a scheme shortly. The principle of the system is to measure the heating up gradient of the soaking pit over a small temperature range from 1,100 to 1,150°C. From the results obtained a reasonably accurate prediction of the time that rolling temperature will be attained can be made.

A great deal of experience has recently been gained in the techniques of electrical weighing using loadcells. The pillar and toroidal types of cell were briefly described and some reference was made to the pitfalls and difficulties encountered when mounting loadcells. Slides were shown illustrating several existing weighing systems describing precautions taken to overcome overload, shockload and non-axial loads being transmitted to the loadcell. When loadcells were first introduced tremendous economic advantages over other types of weighing systems were anticipated. Owing, however, to expensive mounting arrangements now found to be required these advantages have almost disappeared.

A device has recently come on the market which seems to offer more promise than a loadcell. This device, of Swedish origin, is called a "Pressductor" and in principle is comparable with a mismatched transformer. The makers specify that no zero drift is apparent up to 80°C, an overload of 400% can be tolerated, accuracy of better than ½% is claimed and an electrical output of up to 1 volt is possible. The unit is in use on the continent for measuring rolling mill and crane loads.

Flying micrometers are used to measure low tolerance razor blade strip. Nucleonic gauges have been tried, but they were found to be insufficiently accurate. X-ray gauges were under consideration for use on a hot plate mill and one make of this type of instrument was described.

Finally, Dr. Baulk introduced the latest and most ambitious instrument scheme yet to be installed at the Samuel Fox works. This is a computer-controlled billet cutup line which is designed to achieve the minimum billet waste. The principle of the system is to first measure the length of a billet as it leaves the billet mill and feed this information into the computer. Previous information relating to the customer's order in the form of the number and tolerance of the billets is also fed into the computer. The computer is programmed to work out the most economical lengths at which to cut the billets. Two saws are used, one to cut lengths from 30 ft down to 10ft and the other to cut lengths from 10 ft down to 18 inches. The computer-calculated information is displayed at both saws in the form of a digital display which indicates the current and next orders.

A further extension of the installation using spare computer capacity is contemplated in the near future. The extension will eventually link up the processes carried out by a blooming, intermediate and finishing mills.

In summing up the lecture the chairman thought that all credit was due to Samuel Fox & Co. for breaking into the new field of computer control and no doubt further installations would be considered in the near future. At the start of the lecture Dr. Baulk had referred to himself as Daniel entering the lions' den for speaking about steelworks instruments in a steel-making centre. Judging by the number of questions asked at the end of the lecture, the fare provided by Dr. Baulk satisfied the appetites of most members.

Tees-side Section

In the presence of 13 members and 19 visitors, Mr. B. W. Ramsay, Section chairman, opened the 98th ordinary meeting and introduced the speaker for the evening, Dr. P. A. Young, general manager of the Research and Development Division of Head Wrightson & Co. Ltd.

Dr. Young commenced by outlining the major changes in steel-making techniques since the days of the invention of the Bessemer and Thomas processes, and then proceeded to describe the two most recent advances, both of which use large quantities of high purity oxygen in order to produce high grade steel much more quickly then previous methods. In one, the so-called L.D. process, a fixed vertical furnace containing the melt has a jet of supersonic oxygen directed through the slag from a water-cooled lance. The second, less violent reaction known as the Kaldo process, takes place in a furnace rotating about its axis at about 30° to the horizontal, and in this the process is more a diffusion of oxygen from the lance through the slag. Because of the characteristics of this second reaction, more of the oxygen had a chance of reacting with the carbon monoxide within the furnace, thus making available more heat for the melting of scrap.

In both processes, melts of as much as 400 tons are handled and in the Kaldo process the furnace is rotated at up to 300 rev/min. Failures of linings in the latter are known to be due to the higher temperature within the furnace rather than being due to the rotation.

The difficulty of controlling these processes arises from the very high speed of reaction: for example, a melt in the L.D. process which would take one hour to convert, would take 12 hours by the open hearth process. It is therefore important that such factors as temperature, rate of oxygen and analysis should be accurately controlled, otherwise the end product would be off specification. Another important variable which must be accurately controlled is the weight of the melt and it is essential that melts of 100 ton should be known to better than 0·1%. The addition of lime, ores and fluxes by auxiliary weigh hoppers must also be stringently controlled. One particular installation at the Royal Dutch Steel Works, which weighs by means of loadcells, was designed to give an accuracy of 60 kg in 100 tonnes and has in fact achieved an accuracy of 80 kg.

As these processes proceed, samples are taken and the results of analysis are known within two minutes and from this the remainder of the process can be determined. This is of course very complicated and one firm in the U.S.A. devised a 6 ft long slide-rule for the job, but this proved so complicated to use that they are now following the Dutch example of using an analogue computer.

As yet, there is no means of obtaining a continuous temperature record of a melt at 1,600°C and pyrometers have on the whole been unsuccessful. However, Dr. Young mentioned that if the pyrometer is placed sufficiently far away so that it sees the whole flame rather than just a part of it, then quite accurate results can be obtained.

Due to the very large quantity of submicron iron oxide produced at very high temperature in these reactions, very extensive auxilary equipment is required to cool and clean the gas before venting to atmosphere. In fact, on one 100 ton plant the auxiliary equipment had cost more than the converters themselves.

The very lively and interesting discussion was opened by Mr. T. B. Kent, and the vote of thanks proposed by Mr. T. W. Bain was very heartily supported.

In the presence of 17 members and 2 visitors, Mr. B. W. Ramsay, Section chairman, opened the 99th ordinary meeting and introduced the speaker for the evening, Mr. E. N. Martin, of I.C.I., Billingham Division.

Mr. Martin commenced his lecture "Some Impressions of Instrumentation in the U.S.S.R." by outlining the nature of the symposium he had attended and how this had been attended by about 1,100 delegates from 46 countries.

The lecturer then described how the Russians were using pneumatic components rather than electronic ones in certain of their computers. The main reason given by them for this was that quite often you need only a relatively slow speed

Circle **374** for further information

Straight from Prague
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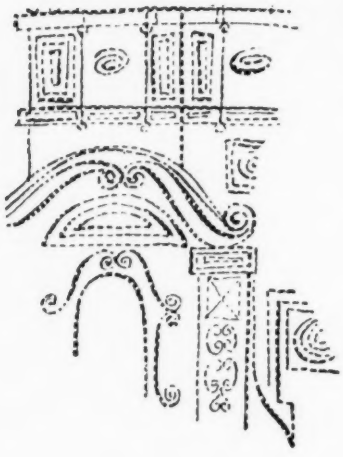

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Designed by Professor Jaroslav Heyrovsky, the Nobel Prize Inventor of the Polarograph, the Kovo comes direct from the manufacturers in Prague—the home of Polarography.

A 50 c.p.s. A.C. is superimposed on a polarographic electrode system. During each cycle the polarizable electrode is charged from 0 to -2V, and then back again from -2V to 0. The oscilloscope shows dV/dt (vertical) against V (Horizontal). The oscillogram for a pure carrier electrolyte has an oval shape, its upper half is the cathodic branch, the lower the anodic. When a depolariser is present the curve indicates incisions as shown above. Their depth is proportional to concentration. If displaced horizontally it indicates that the electrode reaction is not reversible. The instrument is suitable for analysis in the range 10^{-3} to 5×10^{-8}M. By use of electrolyte concentration (Switch 'MICRO' on the instrument) or by a hanging drop method, 10^{-9} can be reached. A mechanical drop time controller varies the drop time between 1 and 7 seconds. Comparative titrations can be performed by using twin electrode systems, and observing two oscillograms displaced horizontally. Titrant is added until the depth of incisions coincides. Isomers and compounds of similar structure can be very easily examined and identified.

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of response which can quite easily be achieved pneumatically and that pneumatic devices are more reliable than electronic ones. However, Mr. Martin thought that part of the reason was that the Russians appeared to be behind the West in electronic know-how, particularly in the preparation and use of solid state devices. For this pneumatic work, a number of interesting new components have been devised, in particular an aerofoil relay, no bigger than a peanut, in which there are no moving parts, and which is capable of 10 operations per second.

A self-optimising controller was also described which increased the output of the plant by 10% when working on a new catalyst and by 15% to 20% as the catalyst deteriorated. One of the other dynamic optimisers described computed the required rate of climb of a missile or aircraft in relation to the variation of density with altitude.

Mr. Martin went on to describe the visits he had made to the Institution of Automation and Remote Control in Moscow and to the corresponding organisation in Kiev. The former dealt mainly with the pure aspects of the subject whereas the latter was more interested in applications. The Kiev organisation had grown from 400 technologists in 1958 to 2,000 in 1960, and aimed at 6,000 by 1965. However, they were finding a certain amount of difficulty in recruiting sufficient competent staff.

Mr. Martin had also visited a power station where he had noticed that most of the controls were electrical but unfortunately he had not had an opportunity to visit a chemical plant, an oil refinery or a steelworks.

The lecturer concluded by commenting on the competence of the staff he had met, of how well the equipment was constructed and on the plentiful supply of text books and translations of all Western publications.

The discussion was opened by Mr. J. W. Jackson, and in the course of this Mr. Martin mentioned that he had the impression that instrumentation on process plants was centralised in control rooms but that miniaturisation had not been taken so far as in the West.

The vote of thanks was proposed by Mr. J. M. Plews and was warmly supported.

The technical meeting was followed by the A.G.M. and the committee is now as follows:

Chairman:	B. W. Ramsay
Vice-chairman:	V. H. Brown
Hon. Secretary:	V. Willis
Hon. Treasurer:	A. McDonald
	T. W. Bain
	D. M. Bishop
	H. A. Horton
	L. Ludbrook
	T. R. Peacock
	T. W. Randle.

Annual Dinner

On 9th March, at the annual dinner of the Section, the toast to the Society of Instrument Technology was proposed by Mr. P. M. K. Embling, director and general manager of the Power-Gas Corporation.

Mr. Embling spoke of the importance of providing engineering with straightforward, simple, reliable equipment which would do jobs without lots of frills.

The aim, particularly with export business, should always be to provide this simplicity and effectiveness without over-elaboration.

In the export business, it was becoming more and more a case of exporting brains, and for that reason alone the instrument industry would play an increasingly important part in the trade of the country.

Mr. Embling also spoke of the increasing importance of instrument engineering in industry and of its role in the conquest of space and even in the home. He said that the specialists of instrument technology should try to explain their skills in simple terms to the managements of smaller companies which did not have specialist departments to deal with these matters.

He also suggested that although a great deal of knowledge in instrument engineering came from the United States, recent events in Russia had shown that there might be something to learn from the East as well as the West.

Responding, the President of the Society, Mr. G. C. Eltenton, said that the age of instrumentation now existed but that not enough appeared to be done by the Government to aid in educating people for industry.

He said that the Society was considering how more training and education in the technology could be applied to provide sufficient skilled people.

Referring to the Tees-side Section, Mr. Eltenton said that it was one of the most active Sections in the country and had provided some very able men for the Council.

The toast to the guests was proposed by Mr. B. W. Ramsay, Section chairman.

Mr. P. A. Negretti, chairman of Negretti and Zambra Ltd., responded.

(*Continued from page* 629)

Shockley Four Layer Diode

An application data sheet on the Shockley 4-layer transistor diode is now available from the Brush Crystal Co. Ltd.

Circle **78** *for further details.*

Furnaces

A horizontal general purpose electric furnace with a maximum operating temperature of 1,050°C and a vertical general purpose electric furnace with the same maximum operating temperature are described in leaflets from Wild-Barfield Electric Furnaces Ltd.

Circle **79** *for further details.*

Avo International Transistor Data Manual

This publication provides information on approximately 3,000 transistors and includes obsolete, obsolescent, current production and prototypes. Data from 90 transistor manufacturers and distributors is listed, including those of American, European, Japanese, Australian and East European origin. In addition, information is given on transistors having Services Common Valve Specifications. This publication thus provides a comprehensive guide in a compact form. The price is 35/-, post free.

Circle **80** *for further details.*

F.H.P. Motor

A new f.h.p. servo motor and motor generator leaflet IG. 343 has just been published by Evershed and Vignoles Ltd., giving brief details of the wide range of Evershed motors now available. This includes a.c. and d.c. servo motors and motor generators; special purpose motors; tacho generators; gearheads and torque transmission units as well as amplifiers and power units.

Circle **81** *for further details.*

Liquid Metering and Dispensing

"Liquid Metering and Dispensing" is the title of a 16-page illustrated brochure now available from Parkinson Cowan Measurement.

The first of a series of three, this new brochure outlines the construction and application of Parkinson Cowan Measurement meters for both water and industrial liquids. There is also a section describing some of the many indicating and control devices which can be used with the meters.

"Pumping" will be the second brochure in the series and "Instrumentation" the third.

Circle **82** *for further details.*

Counting and Linear Measuring Machines

Trumeter's range of counting and measuring equipment are described in a 16 page catalogue No. 61/1. The range includes speed indicators, revolution, textile and printer counters, counters for conveyors and electric counters.

Circle **83** *for further details.*

EMI Electronics' Industrial Newsletter

Spring issue of EMI Electronics' Industrial Newsletter concentrates on showing how savings can be made by using electronics in industry.

A satisfied customer—Mr. K. Teale, of Short Brothers & Harland Ltd.—describes how his company has reduced its scrap rate to 0·3% by using an EMI-controlled Cincinnati milling machine. Results have been so satisfactory that Shorts have ordered a second machine.

In another feature, some comparative statistics are given to show the considerable economies obtained when carrying out typical drilling operations on EMI-controlled machines instead of by conventional methods.

Recent applications of Robotug driverless trolleys, rotary tables and commutator undercutters all over the world are also reported, and details are given of EMI's latest dynamic balancing machine.

Circle **84** *for further details.*

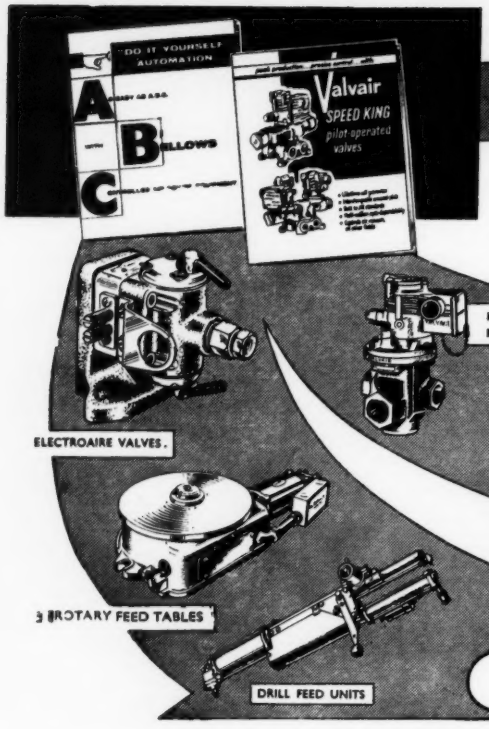
TMC Technical Journal

Among the articles included in the March, 1961, issue of this journal is:

"Performance Factors Applied to Polarised Relays" by P. P. Eckersley, M.I.E.E., F.I.R.E.

Circle **85** *for further details.*

Circle **375** for further information



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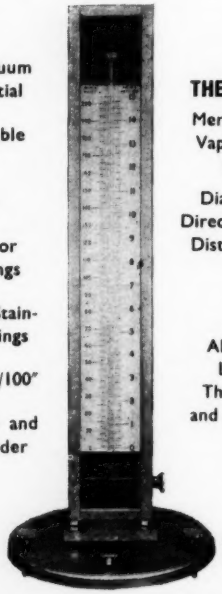

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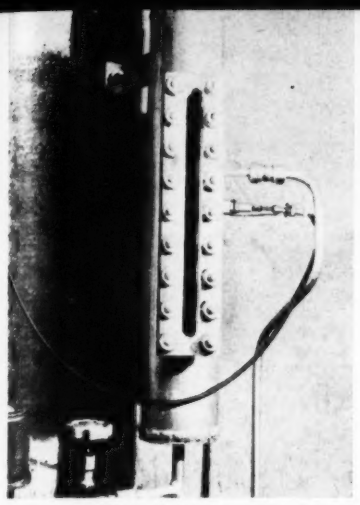


The modified sparking plug "probe" is on the right of the sight glass to which is connected the Proximitor capacity operated relay

Proximitor Detects Interface Between Oil and Water

THE necessity for separating gas, oil and water in an oil cracking process at the Sunbury Research Centre of the British Petroleum Co. Ltd. set its own particular problem when it became necessary to detect the interface between oil and water. Due to the tarry nature of the oil, any sight glass became quickly fouled. Conductivity measurement was tried but proved unsuitable since the tarry oil coated the probe and interfered with the detection.

The problem was then discussed with Electronic Machine Co. Ltd. with particular emphasis on the possible use of their Proximitor capacity operated relay. A sparking plug was modified for use as a probe in conjuction with the Proximitor unit, with the result that, as the aqueous layer reaches the probe a relay operates, due to differences between the dielectric constants of the aqueous and oil phases, actuating a magnetic valve which controls the water off-take. The aqueous phase often contains small amounts of emulsified oil but the presence of this has not affected detection of the interface.

The Proximitor can, of course, be used for many other types of application, such as the sensing of metal markers on paper or valve chamber monitoring and when used with a suitable batchcounter is capable of sensing up to as many as 12,000 objects per minute.

Circle **86** *for further details.*

Chromatographic Analysis in Chemical Intermediate Manufacture

ABOUT 40 chemical intermediates are currently manufactured at the Castleford works of Messrs. Hickson & Welch Ltd. and most of these are based on nitration, chlorination, or reduction reactions with benzene, toluene and xylene. These intermediates are produced to a high degree of purity and careful process control is necessary at all stages of production to ensure constant high quality products. During these processes careful analysis is required and in many cases gas chromatography using the high sensitivity argon ionisation detection system has been found to be the only method giving a sufficiently high degree of accuracy and reproducibility. The part played by gas chromatography in process control may be illustrated by its application during the production of ortho- and para-nitrotoluene.

It is essential that the toluene used be of a high purity and in particular the amount of benzene present must be below 0·02%; all toluene to be processed is examined by gas chromatography, less than 0·01% of benzene being detectable. The mixed nitrotoluenes produced by nitration are fractionated and crystallised to produce ortho-, para- and meta-nitrotoluene. At all stages samples are taken for analysis in order to assess the efficiency of the operation. In the case of ortho-nitrotoluene traces of meta- and para-nitrotoluenes, nitro-benzene and non-nitratable materials can be detected when present at less than 0·05% of the total.

Messrs. Hickson & Welch Ltd. have installed a number of Pye argon chromatographs to provide the accurate and reproducible methods necessary to analyse the high quality products required for sale and for subsequent manufacturing processes.

Circle **87** *for further details.*

Heart Operations to be Centrally Monitored.

FIRST of a new type of central monitoring desk, containing all the monitoring equipment used in modern heart operations, has been commissioned in the Department of Surgery (D block) at Hammersmith Hospital in West London.

The desk is in a recording room that serves two operating theatres and a recovery ward. Duplication of much equipment is thereby avoided and only one person is required for monitoring.

Greater use of electronics in operating theatres today has brought problems of overcrowding, risk of infection as a result of electronic apparatus being brought into the theatre, and the need for simple interpretation of measurements. The new centralised monitoring technique will meet these problems and provide all information on a single console. Recorders, oscilloscopes, adjustable controls and switches, amplifiers and other units are all outside the theatre; multi-way cables connect them to the patient and an intercommunications system links the surgeons with the recording room. Really essential measurements are repeated on large meters and oscilloscopes in the theatre, easily seen by the entire surgical team.

This centralisation is thus a logical development arising from the growing use of electro-physiological equipment in cardiac centres, in association with heart-lung machines and hypothermia units.

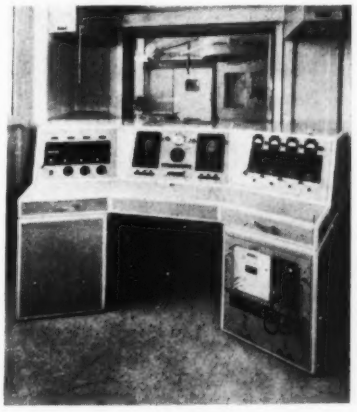
The Hammersmith installation will, for the first time in any cardiac centre, provide remote recordings of the e.c.g. arteria and venous pressure in ancillary rooms and recovery wards as well as theatres. It goes much further in specialised instrumentation for cardiac surgery, e.g. mammoth three metre "clock dial" surgeons' pressure indicators, the repeat venous and arterial blood pressure measurements in the heart-lung machine operation, the duplication of oscillographs and the use of remote oscillographs for e.c.g., e.e.g., and pressure displays. It is also the first step in "automatic operations" in that a remotely controlled and calibrated tap unit has been developed.

The desk and its equipment were supplied by New Electronic Products Ltd.

The middle of the desk contains two twin channel oscilloscopes allowing four waveforms to be viewed simultaneously, and each amplifier channel has an indicating meter. Permanent records are made on a six channel photographic recorder located lower right. Eight amplifier channels are fitted upper left and right, any six of which may be used to link the recorder with any of the rooms of this cardiac centre.

Amplifiers, electrodes and transducers are supplied for transmitting electrocardiograms, phonocardiograms, intercardiac pressures, electro-encephlographs, external cuff blood pressures, pulse waveforms and blood pH. Other physiological measuring facilities will in due course include a Honeywell multi-point strip chart recorder for measuring and recording blood, air and surface temperatures. This is particularly useful where hypothermia techniques are used enabling a complete check to be made of the patient's temperature fall rate in the operation theatre and the patient's subsequent temperature rise rate.

New centralised monitoring desk at Hammersmith Hospital



A dye assembly can also be included in the desk with connections to the Norman N.E.P. dye earpiece or cuvette on the patient in the investigation room. A strip chart recorder is also used here.

Working in conjunction with the pressure amplifiers are mean pressure indicators giving the desk operator immediate visual indication of inter-cardiac and external cuff pressure. Other larger pressure indicators situated within the operating theatre or investigation rooms are also provided. A switch unit connects appropriate pressure amplifiers to the required indicators, avoiding the need to have an indicator for each pressure amplifier.

A full system of interconnection is provided to enable any physiological measuring circuit to be connected to the appropriate room of the cardiac centre. The same circuit output is fed into the photographic recorder, control oscilloscope and repeat or display oscilloscope. In the case of pressures, the outputs can also be fed to one or more indicators. Each switch unit, under its amplifier, is engraved so that the use of a particular amplifier is known from the switch positions. Each amplifier panel, oscilloscope and recorder has its own controls for balancing, beam control, chart speed selection. These particular controls are, of course, set before monitoring begins and do not normally need readjustment during the time the desk is in use. The tap unit controls are also situated near the pressure amplifier selection control so that all controls for this particular type of measurement are together.

The intercommunication controls have been simplified so that each room may be selected individually or the cardiac centre connected as a whole.

Circle **88** *for further details.*

Cabin Pressure Control System

KELVIN-KOLLSMAN cabin pressure control system is to be fitted in the five de Havilland Comet 4Cs for R.A.F. Transport Command. Similar equipment has already been specified for B.E.A.'s Tridents, and for the R.A.F's Belfast strategic freighter being built by Short Bros.

The system is based on the KS-69 cabin pressure control system developed by Kelvins' American associates, the Kollsman Instrument Corp. of Elmhurst, New York. Its chief advantages are: flexibility of control, high speed of response, light weight and small space requirements, minimum of pneumatic piping, and minimum of maintenance attention.

Control of the cabin pressure is achieved by three series-connected, capsule-type monitor elements which convert pressure into electric signals. By combining these signals and amplifying the resultant to drive an electric actuator, the discharge valve is positioned to control air flow overboard within specified limits. A motor - operated discharge valve trip mechanism and altitude switch are included in the system for abnormal or emergency conditions.

The discharge valve is the butterfly type. A special feature of its construction is that the bearings supporting the butterfly shaft are located outside the airflow tube and, therefore, are not subjected to gum and tar accumulates. Hence there is no need for filters to remove these contaminants from the air before it passes through the valve.

Total weight of the components forming the basic system is approximately 26½ lb.

Circle **89** *for further details.*

Materials Handling Problem Solved with Vibrator Motor

A SIMPLE and effective solution to the frequently met problem of dislodging material stuck in a hopper has recently been found in a series of experiments with an English Electric vibrator motor. The experiments were done on a hopper handling filter cake at a fertiliser factory in the north of England.

In the process the filter cake flows from the hopper on to a short feeder conveyor incorporating an electronic probe which detects whether or not the material is still flowing. Before the vibrator was installed, the detector operated an alarm which gave an audible signal when the flow stopped. An attendant then had to climb steps from the factory floor to the hopper platform and hit the sides of the hopper with a hammer to start the flow again. The moisture content of the material varies considerably and under certain conditions this had to be done at frequent intervals.

Not only did this interfere with production, it also caused severe damage to the sides of the hopper. It was, in fact, necessary to renew the side panels from time to time, which meant emptying the hopper, burning out the damaged panel and welding in a new one.

In the first experiment a ¾ h.p. 3,000 rev/min vibrator motor was bolted to a ¾ in. steel plate of about twice its own length, and the complete assembly then bolted at its extreme ends to the side of the hopper about half-way up. The resultant "flapping" effect of the centre of the plate against the hopper was sufficient to maintain the flow of material. A short burst of a few seconds' duration every few minutes was found adequate.

Further experiments were carried out to produce a completely flexible system of operation and in the final installation three methods of control were incorporated:

(a) a manual push-button starter under the control of the operator
(b) a timer unit which automatically operates the vibrator motor for 10 seconds every 10 minutes and
(c) a relay controlled by the electronic probe, which operates the vibrator in the event of an interruption of the flow of material between the automatically timed bursts.

These three methods of control are connected in parallel and are, therefore, supplementary. The installation maintains the flow of material without attention.

Circle **90** *for further details.*

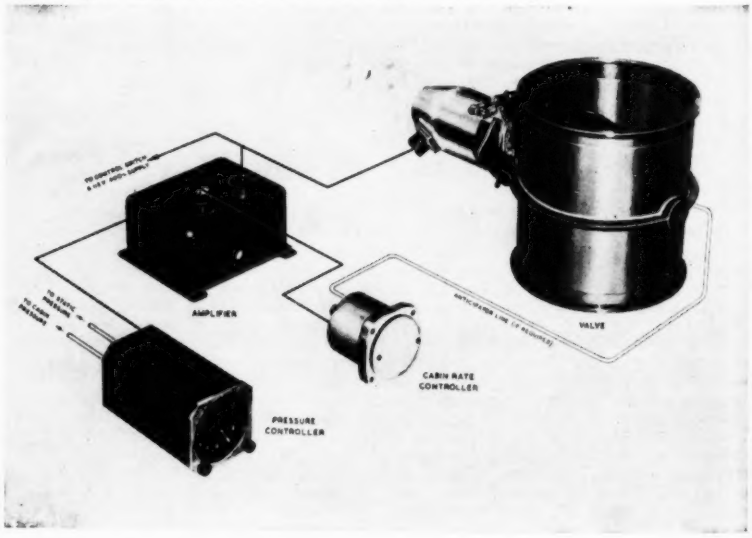
Closed Circuit TV for X-ray Diagnosis

DIAGNOSING of illness is becoming easier and quicker for the patient and radiologist with the recent development of using an EMI Electronics closed circuit TV camera fitted to a Siemens electron-optical image intensifier. The picture is displayed on a high definition monitor screen in the X-ray room and can either be viewed there or in other rooms, such as lecture theatres, some distance away from the room in which the examination is taking place.

Use of TV means that the examination can now take place in a lighted room instead of in complete darkness. Previously, the viewing facilities limited the number of observers, but now large screen presentation allows any number of medical personnel to observe the progress of the examination simultaneously and without hindering the work involved.

A high-class Vidicon tube is used to view the low light level intensifier picture. Variations in the brightness level resulting

Basic components of the Kelvin-Kollsman cabin pressure control system



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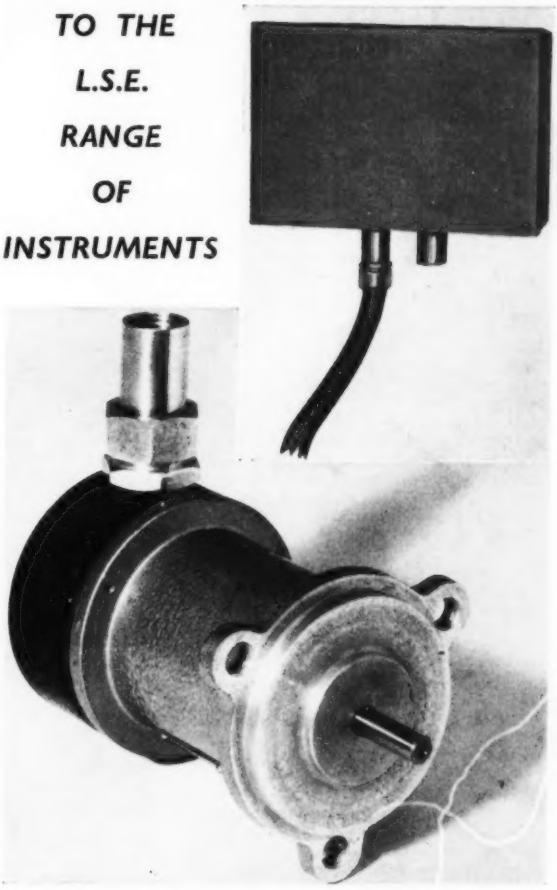

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Peak to Peak Ripple Content:
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from differences in thickness of the body section being examined or from natural body movement, such as breathing, are compensated for within the TV channel by using an automatic brightness control.

Complete equipment is compact and easy to operate. Permanent records of interesting details can be made by replacing the TV camera with a ciné-camera.

Circle **91** *for further details.*

Quality Control System for Sheet Metal Industries

A NEW quality control system for the sheet steel and tinplate industries is being produced by the Metal Industries Division of English Electric. This new sheet metal classifier is used for sorting sheared sections of cold strip and rejecting faulty pieces.

Faults such as pinholes, off gauge and poor surface finish are detected during the inspection of the continuous strip. The sorting into grades can only be done, however, when the strip has been cut into individual sheets.

The sheet classifier stores the information on strip quality obtained at the time of inspection and uses it when the sheet is cut and ready for sorting into piles. The information is stored and processed by Datapacs, standard transistorised logical elements.

From these standard elements a sheet classifier system of any size and complexity can be built, for a line of any speed and with cut length ratio of as much as 10/1. The first units will shortly be installed on number five cut-up line at the Abbey Works of the Steel Company of Wales Ltd. and on two cut-up lines at Richard Thomas and Baldwins Ltd., Ebbw Vale. A further unit is to be installed in a South African steelworks.

The unit at the Abbey Works will be on a steel line operating at 700 feet per minute with cut lengths ranging from 40 in. to 180 in. Sorting will be into rejects and prime sheets.

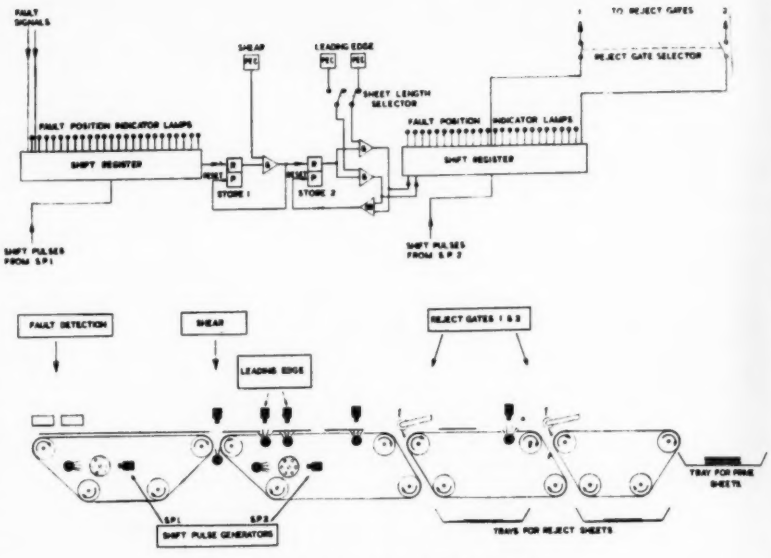
On two tinplate lines at Ebbw Vale, both operating at 1,000 feet per minute and with cut lengths ranging from 18 in. to 42 in., sorting will be into four piles: sheets with pinholes, off-gauge material, other rejects, and prime sheets.

Method of Operation

The Datapac standard logical elements are in the form of standard plug-in packages. Each package contains a number of elements capable of performing a specific logical function, e.g., shift register, "and" gate, store, etc. Each element can operate from the output of the preceding element so that a series of elements can be made up to form any desired logical system.

Faults detected by the instruments are stored in the first shift register at a point corresponding to the instrument position. Shift pulses timed to the conveyor movement are applied to the register so that the fault signal moves within it in time with the movement of the faulty section of strip on the shearing line. The signal transfers from the register to " store 1 " when the fault passes the shear position. This then indicates that the next sheet to be cut is a reject.

When a sheet is cut, this is detected by a device which causes the signal to be transferred from " store 1 " to " store 2 ". This indicates that the last sheet cut is a reject. The leading edge of this reject sheet is now detected by one of the leading edge detection photocells and transferred to a suitable position in the second register. The signal of the reject sheet is then shifted within the second register so that it appears at a reject gate just before the leading edge of the sheet reaches the gate. The signal is used to prime the gate control to reject the sheet when its leading edge reaches the gate photocell.



Operation of a typical sheet metal classifier

Two leading edge photocells are used after the shear to cover the range of sheet lengths used. One is used for short sheets, the other for long sheets. Either is suitable for sheets of medium length. Selection of the photocell is automatically done by the shear cut length setting.

Normally mechanical reject gates are used, but more complex methods such as overhead magnetic conveyors with variable drop off-points for the piles can be operated with the new system.

Circle **92** *for further details.*

Stable Power Supply for Fisheries

WITH the introduction of new electronic equipment capable of precision measurements in oceanic waters, the existing 240 volt a.c. supply on the R.V. *Ernest Holt* used for fishery research in Arctic waters was found to be unsuitable. It became necessary therefore to replace this equipment by a new system that would have ample capacity as well as the desired voltage and frequency stability.

The system finally decided upon was provided by a Crompton Parkinson 15 kVA motor alternator set embodying a self-regulating alternator which is designed to regulate the alternator frequency within 1% of the nominal frequency of 50 cycles by use of a Brown Boveri frequency regulator. The terminal voltage is constant within $\pm$ 2%.

The new system has been installed with a view to providing a well-regulated a.c. power supply that will have sufficient capacity to cover all foreseeable power requirements during the next ten years. At present, this system will be used to supply experimental electronic devices which are sensitive to both voltage and frequency variations in the common power supply. These equipments are capable of measuring profiles of temperature and depth, velocity and direction of ocean currents, echo soundings, and conductivity of sea water.

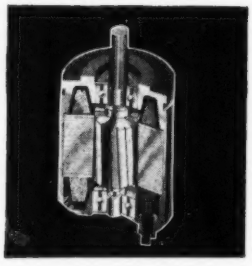
The information given by the various equipments is recorded permanently on strip chart recorders, the accuracy of which (in terms of time) depends on the value and stability of the power supply frequency. This alone makes it essential for the frequency to remain stable.

The accuracy of these readings can be seriously affected by electrical noise and the elimination of this interference is a factor that has to be taken into consideration.

With many electrical devices running continuously on the ship, it has been found impossible to suppress completely each individual source of electrical noise generation. It was therefore necessary to isolate completely the a.c. power system for the scientific supply and use screened wiring throughout, with only one common earth connection wired back to the alternator. This arrangement allowed for simple suppression of the motor alternator and prevented interference from the d.c. bus bars being induced in the a.c. supply.

Circle **93** *for further details.*

Circle 380 for further information



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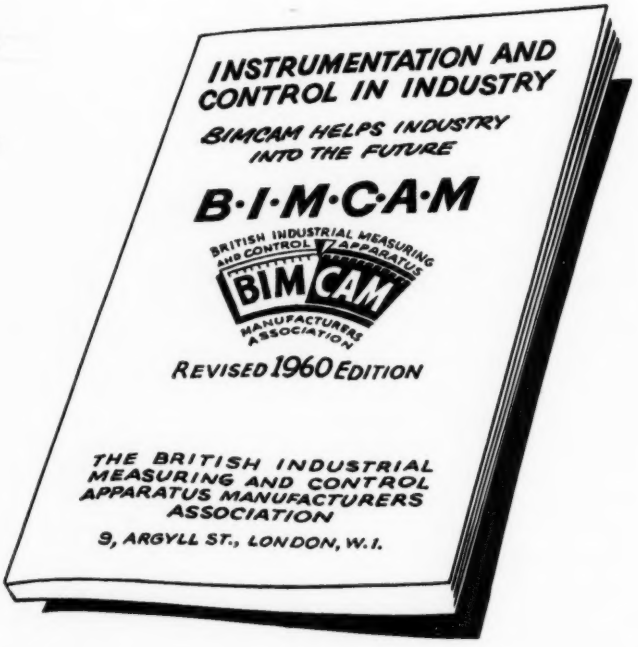
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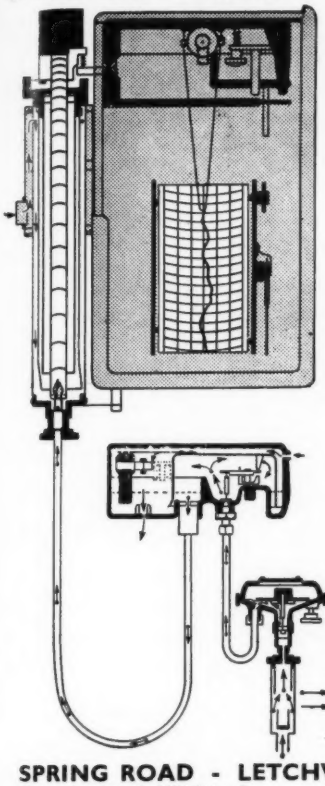

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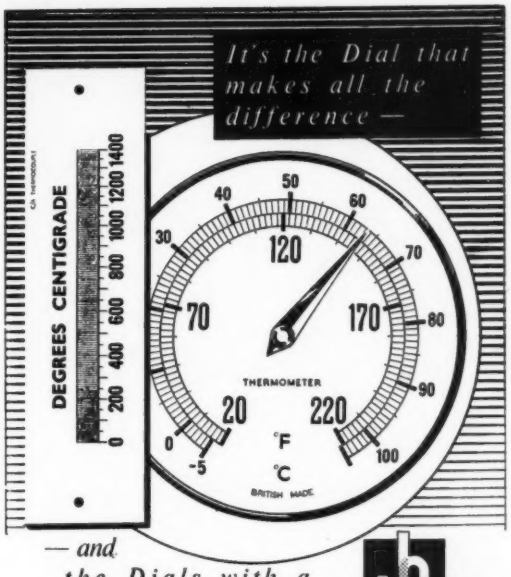
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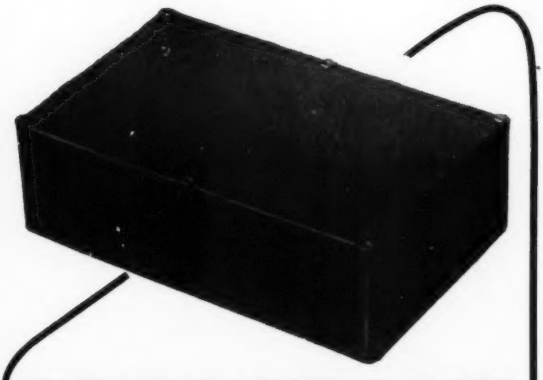

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A. A. New, M.Sc., F.R.I.C., A.Inst.P

Precision Wirewound Resistors
D. C. F. Bartlett, B.Sc.(Eng.), M.S.M.A.

Microminiaturization, Reliable Components and Cooling Techniques
G. W. A. Dummer, M.B.E., M.I.E.E., Sen. Mem. I.R.E.

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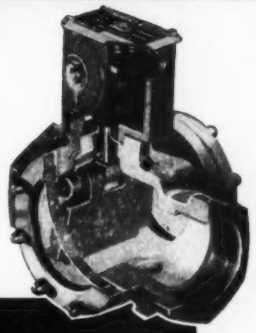

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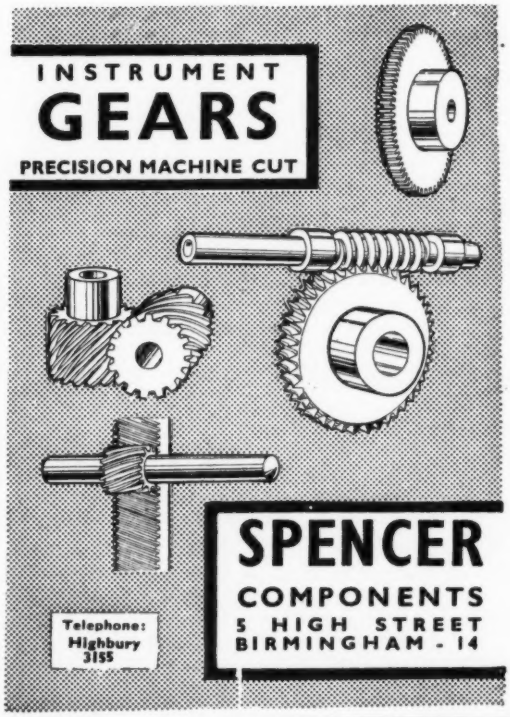

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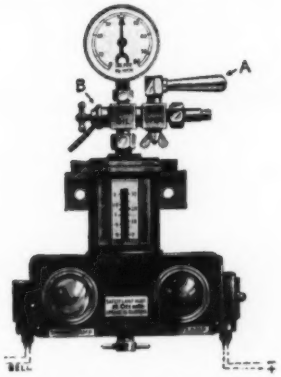

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The commencing wage will be 77s. 3d. per shift, plus a variable cost-of-living allowance, at present £5 4s. 0d. per month, plus a variable bonus related to the profits of the company. The bonus is, at present, 9·6% of basic wage.

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Outward passages for successful applicants will be paid by the Company.

Applications in writing, stating qualifications, experience, age and marital status, should be addressed to:—

Appointments Department (G),
Rhodesia Broken Hill Development Company, Limited,
40 Holborn Viaduct,
LONDON, E.C.1.

RHODESIA BROKEN HILL DEVELOPMENT COMPANY, LIMITED

Northern Rhodesia

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Vacancies exist with the Rhodesia Broken Hill Development Company, Limited, at Broken Hill, Northern Rhodesia, for Assistant Instrument Foremen. Applicants must have obtained a Higher National Certificate or hold a similar qualification.

Applicants should be familiar with the measurement and control of flow, level, pressure, weight, temperature and pH and should have experience in the maintenance and repair of modern pneumatic and/or electronic instruments in heavy chemical or metallurgical plants and should also have experience in the operation and maintenance of highly integrated chemical or metallurgical plant instrument control systems.

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The Instrumentation Engineer would be required to assist in devising instrumentation systems for special problems in the fields of mining, ore dressing, leaching, roasting (fluid bed, hearth and kiln), electrowinning and refining, including measurement and control devices for pressure, temperature, weighing, flow and pulp density measurement, etc. He would also assist with the planning, commissioning and development of instrumentation in the production plants, and with the substantial amount of service and standardisation work which is undertaken.

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APPLY BY AIRMAIL TO: **The Secretaries,**
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Applications, stating age, qualifications and experience, should be addressed to:

Mr. J. E. Wakeford,
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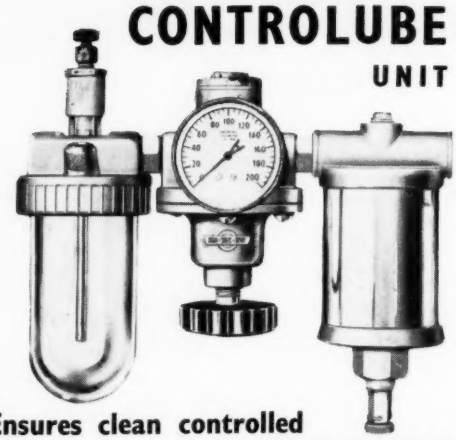

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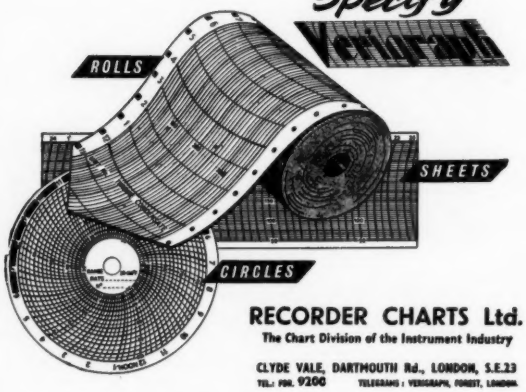

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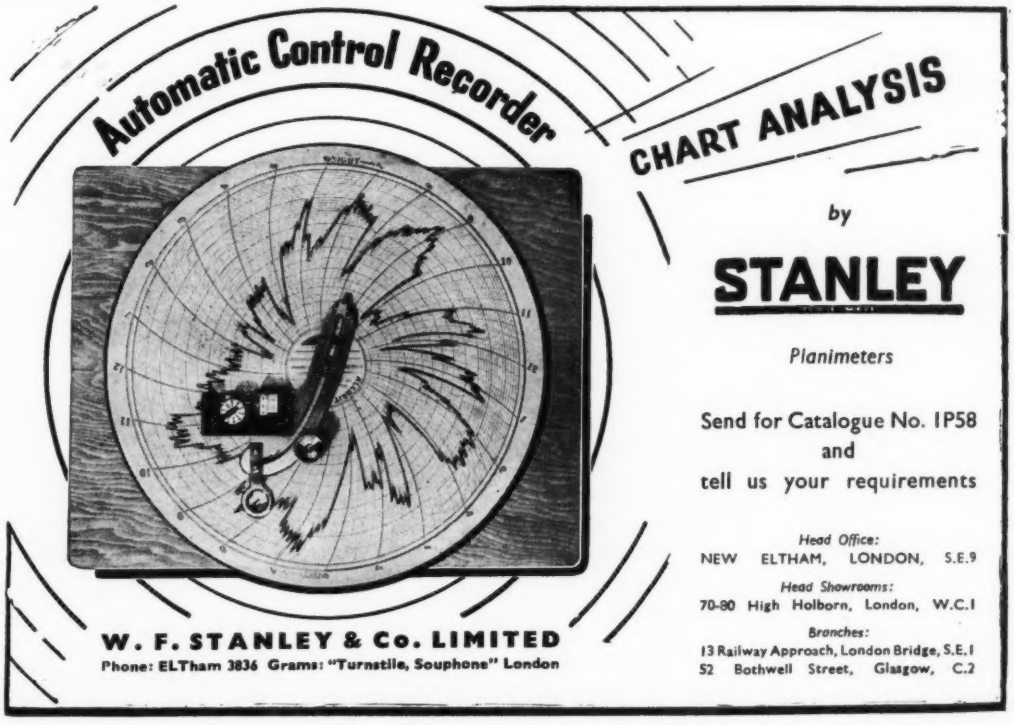

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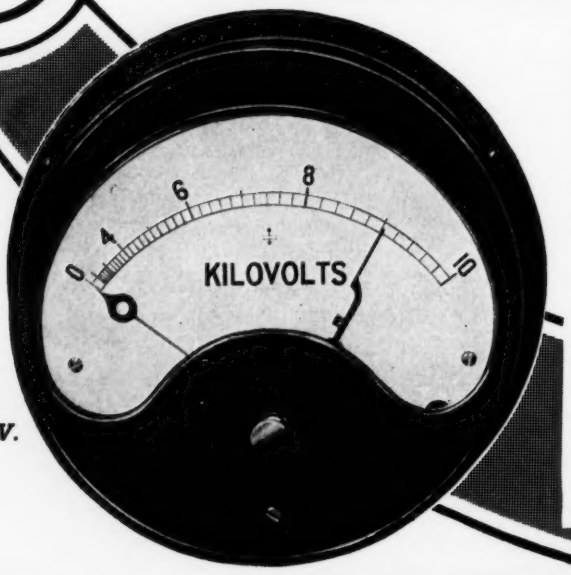

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